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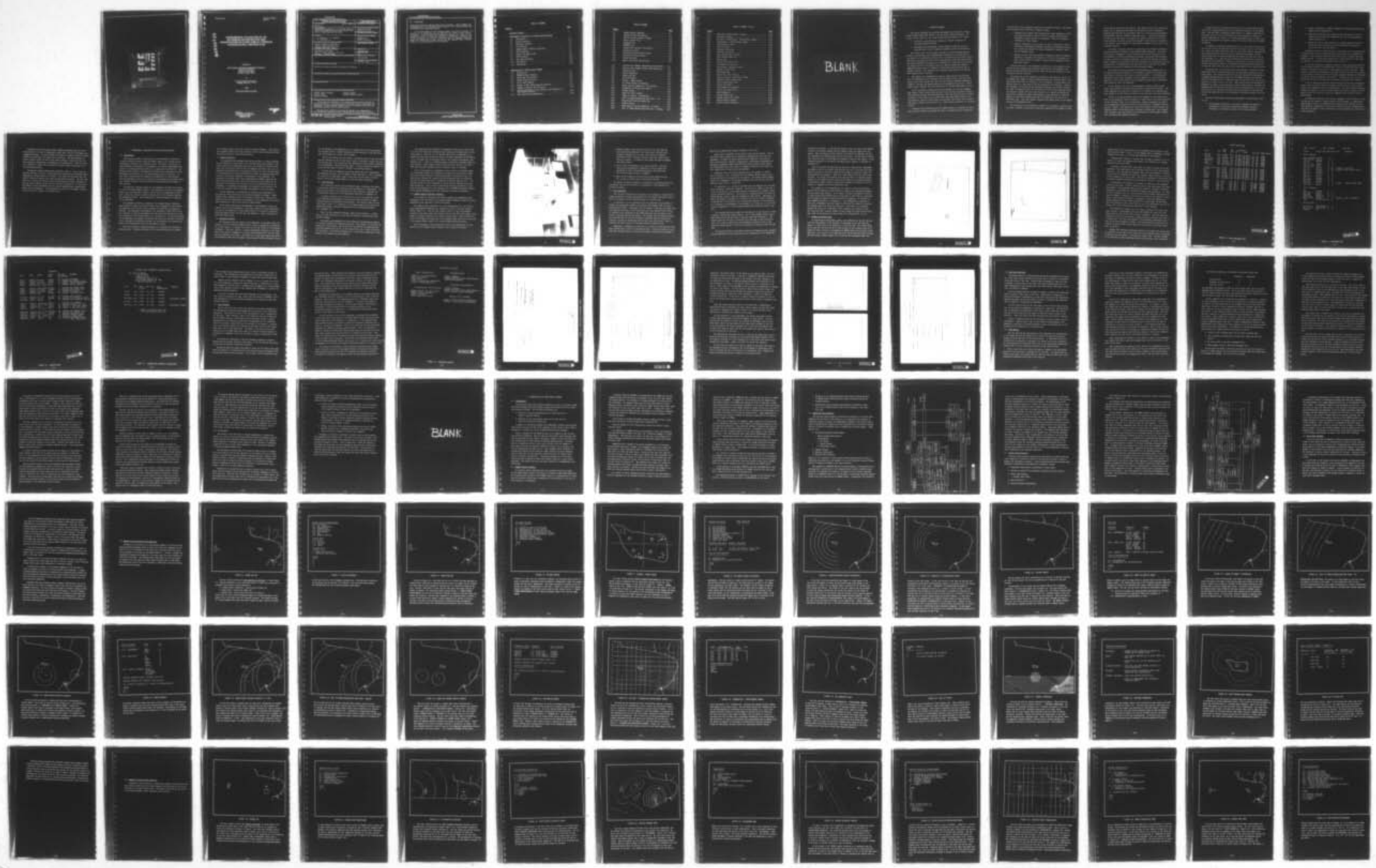

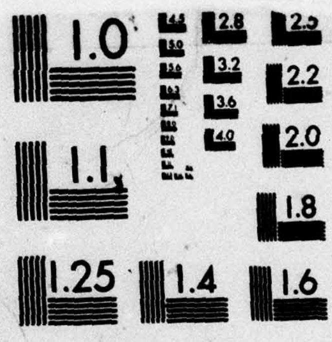

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TECHNICAL REPORT
CSS 77-1

EXPERIMENTAL VALIDATION OF AN OPTIONS SELECTION MATRIX AND INVESTIGATION OF OTHER DISPLAY FORMATS AS OPERATIONAL DECISION AIDS

Prepared for

OPERATIONAL DECISION AIDS PROJECT (CODE 431)
Office of Naval Research
Department of the Navy
Arlington, Virginia 22217

by

Grumman Aerospace Corporation
Bethpage, New York 11714

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This study was conducted to (1) continue work previously started for further evaluation of an options selection matrix and (2) investigate the development of other display formats as aids for decisions which are not adequately supported by the options matrix.

Options matrix validation involved the design of an experiment in which potential operational users, represented by twelve senior officers

20. (Continued)

(both active duty and retired) were used as subjects. Their comments and recommendations as to the operational potential of the options matrix were solicited and are documented herein.

In the development of other display formats, two decision points, i.e., selection of an operations area and selection of a transit route, were investigated. These decisions were examined to determine the types of data required to arrive at a decision, the means of displaying a variety of detailed information, and a way to present the data in a synoptic form which would both include all the data, and provide the commander with a concise display of the data pertinent to his decision.

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EXECUTIVE SUMMARY

This report documents the continued development and validation of Operational Decision Aids (ODA) conducted for the office of Naval Research. The purpose of this portion of the study included the performance of two tasks:

1. Continue the work previously started for further evaluation of an options selection matrix
2. Investigate the development of other display formats as aids for decisions which are not adequately supported by the options matrix.

The initial effort in the design and test of an options matrix was described in the previous report "Experimental Evaluation of an Options Selection Matrix as an Operational Decision Aid," and discussed the technical effort involved in the design and the initial experimentation with the options matrix. The report documented the design of an experiment for conducting a pilot study to evaluate the use of increasing levels of computer support and provide a commander (subject) with an information presentation which would aid him in making a decision. The experiment was evaluated using personnel of the Command Support Group as subjects.

The comments and recommendations made by these subjects were factored into the refinement of the experiment for the present effort, which utilized senior active duty officers and senior retired officers presently employed at Grumman to validate the options matrix as an acceptable decision aid. Twelve senior officer subjects have been tested with the revised experimental set-up.

In the experiment, a decision point was selected at which the commander must choose a ship to detach from his task force and send to perform a mission. This tattletail mission involved detaching a ship from the task force to follow a potential threat ship (e.g., a Kresta with long range SSN-3 surface to surface missile), report his activities, and neutralize the threat if his activity indicated an imminent hostile move (i.e., radar activity indicative of a missile launch).

Scenarios were developed around the ONRODA scenario to describe the situation, and the subject was provided with sets of information which allowed him

to select one of five candidate ships for the tattletail mission. The experiment considers three conditions of computer aiding:

1. Integrated and formatted data presentation, which represents a first step toward automation, wherein data are computed, formatted and displayed as tabular arrays or as graphics. There is no computer assimilation of user inputs.

2. Computer integration of user inputs, in which a checklist of pertinent factors influencing tattletail selection were displayed and the test subject was required to estimate comparative figures of merit for the candidate ships.

3. Computer solution with user selected variables in which the computer calculates, integrates and displays all values for the operator to make a final decision on figures of merit and the weighting of each tattletail factor.

For the first part of the experiment (condition 1), the subject was presented with data displays which provided him with sets of information, but did not provide him with direction as to what data was most pertinent to his tattletail selection decision.

The second part of the experiment (condition 2) provided for the use of the graphic aid, namely an options selection matrix and a factors table. Having the same data sets (as condition 1) at his disposal, he was guided by the factors table as to what type of data was important to his decision. Based on his assessment of the data he now considered pertinent, the subject requested the entry of figures of merit into the matrix for each of the candidate ships, and selected a weight for each of the factors (i.e., acquisition capability, surveillance capability, target neutralization, asset survival and asset importance to own force defense) which must be considered in the choice of a tattletail ship. Then, the computer calculated the result based on his figures of merit and weighting factors.

The third part of the experiment (condition 3), provided an options matrix for which a computer solution had already been applied and the figures of merit

calculated and entered into the matrix. The figures of merit were determined using a set of algorithms which take into account the various parameters affecting the selection of a tattletail ship (e.g., fuel quantity/consumption, maximum speed, weapons, CASREPTS, intercepts, etc.). During the experiment, the subject had the option of accepting the computer (school book) solution to the problem, or he could change those figures of merit which he considered to be invalid. Again weights were subjectively assigned by him to each of the tattletail factors.

To provide a realistic setting for performing the tattletail experiment, subject testing was conducted in our Command Support Simulator. The simulator includes a commander's console from which the subject viewed two group view displays on which were presented the graphic and tabular data necessary for him to review for tattletail selection. He also had available two small screen displays which provided him with the capability of looking at up to four different sets of information at the same time, and a track ball to provide him with an interactive capability with the graphic display.

Test subjects who participated in the experiment are representative of the people who would be expected to be involved in operational decision making and use of decision aids such as the options matrix. In performing the experiment we were most interested in their comments as to the operational potential of the options matrix, and accordingly recorded their conversation both during and after the experiment.

In the condition one part of the experiment, subjects tended to make quick, but relatively inaccurate decisions for the tattletail selection. Subjects commented that there was too much data to consider, and therefore decisions tended to be made based on looking at only portions of the data available.

The use of the options matrix and a set of prompts in the condition two part of the experiment caused the subject to better focus on the data pertinent to the tattletail factor he was considering. Subjects expressed the opinion that determining the figures of merit for the matrix was a somewhat laborious process. However, they agreed that selection of figures of merit becomes considerably easier as the subject gets accustomed to using them. Most subjects felt, therefore, that with practice the options matrix could become a useful tool for making ship selection decisions.

Subjects did not in general accept the use of an options matrix filled in by a set of algorithms as used in the condition three part of the experiment. They felt that a perferable method would be to combine conditions two and three, so that parts of the matrix for which mathematical answers are readily determined are filled in by computer generated figures of merit, and the user would provide the figures of merit for factors which are not readily calculated.

In summary, the subjects expressed the opinion that before he would use the options matrix, the commander would have to acquire trust in its credibility. First, he would have to have faith in the system analysts who generated the parameters and the equations used for obtaining the figures of merit. Then he would have to trust the operators who supply the input data used by the algorithms, i.e., that this data reflects the situation and is properly inserted into the equations. Further, he would have to trust his staff that the selections made by the use of the matrix are indeed the best selections to make and reflect the best choice after consideration of all data available.

The second part of this report deals with the means to provide the commander with aids for decisions which are not adequately supported by an options matrix. Two decision points which had been previously investigated by a Grumman generated scenario similar to the ONRODA scenario were selected. These are the selection of an operations area for the task force and the selection of a transit route to the area. These decisions were investigated to determine the types of data required to arrive at the decision, the means for displaying the various detailed portions of the information and a way to present the data in a synoptic form which would both include all the data and provide the commander with a concise display of the data pertinent to his decision.

The major considerations during the development of these decision aids were to:

- Allow maximum utilization of the user's judgement and skills by implementing an interactive system which permits accepting, overriding, or altering by the user of the processed data.

- Present information in common alphanumeric and graphic formats which expedite user interpretation.

- Build user confidence by providing the user the option to call up varying levels of detailed background data for use in generating a summary presentation.

- Permit the user to refer directly to a computer generated solution for specific minor decisions in stress situations when speed is crucial and work load intolerable.

Although the decision aids developed in this report have a broad spectrum of applications, they were structured around solving the two aforementioned decisions: Best Operations Area and Best Transit Route, centered about the ONRODA scenario. A step-by-step description of their operation in this typical setting is performed to demonstrate user interface.

In the two illustrative examples of decision aiding techniques described in this report, the user is provided with a series of visual aids that he may call up as desired to assist him in formulating his ultimate decision. These consist of interactive alphanumeric and graphic displays in which data germane to the problem at hand has been retrieved upon command, summarized and formatted for quick, precise assimilation by the user. Included, as well, is the capability for the user to exercise trial solutions and analyze their outcome.

A way of summarizing numerical data associated with specific geographical areas is the dot grid in which the density of dots within an area is proportional to the numerical value to be represented. This type of data display expresses the results in a clear, concise visual form that can quickly be interpreted by the user, and can be used by a commander when a decision must be made quickly.

Of additional interest to the tactical commander is the facility to solve and display the results of relative motion vector problems. A computerized maneuvering board type of presentation was employed which provides the user with immediate comprehension of the relative motion involved in hypothesized situations and gives a visual description of the associated time, distance and speed parameters.

Although these data displays present computer processed data and calculated results in an easy to comprehend, visual form, they do not formulate any judgement decisions. The user controls the amount of computer aiding he wishes, selects the input data, and forms his own decisions. The data displays can however greatly reduce the effort that would normally be required by him for data retrieval, organization, condensation, and assimilation. They also serve as a checklist to ensure that he explores the major facets pertaining to the decision-making process.

Although the display formats were structured around solving two specific decision problems, they have a broad spectrum of applications, especially where geographical considerations are involved. This report has presented data displays as they would appear and be used by operational personnel. The next step would be to develop new software and/or modify existing software necessary to generate these displays and provide the interactive capability. At this point the computer sizing requirements and the cost of implementing a demonstration model could be determined. The concluding step would be to implement a demonstration system and conduct a validation test.

1 - EXPERIMENTAL VALIDATION OF OPTIONS SELECTION MATRIX

1.1 Introduction

This section provides a description of the experimental validation of an options selection matrix using the ONRODA scenario and a decision point involving the selection of a tattletail ship. The task is a follow-on to work previously accomplished and documented in our report "Experimental Evaluation of an Options Selection Matrix as an Operational Decision Aid." Our previous effort focused on designing the experiment and performing an initial evaluation using personnel of the Command Support Group as subjects. For this task we incorporated the comments and suggestions of these subjects into the experiment, and have now conducted the experiment using senior active duty officers and senior retired officers currently employed at Grumman as test subjects.

The tattletail scenario chosen for the experiment is within the context of the SRI developed ONRODA scenario. Test scenarios are built on the general scene set by the tattletail scenario and are used for conducting the experiment in which the subject is asked to select one of five candidate ships for the tattletail mission. Three conditions of decision aiding are considered in the experiment.

The experiment itself was conducted in the Command Support Simulator, which houses two large screen and two small screen displays for the subject's use during the test and the control consoles for providing the appropriate displays. The experiment was designed to be conducted in three parts to permit evaluation of subject performance with and without the matrix and to test for acceptance of the selection matrix as a decision aid. The three conditions of the experiment, the graphic and tabular data which are available to the subject for making his tattletail decisions, and the procedure for preparing the subject and conducting the test, are described in detail.

Test data collection consisted primarily of recording the conversation during the test. Subsequent playback of the tapes provided data on elapsed

times between events, data files called and subject comments. Test results are documented based on the data obtained from the tape recordings and from observations made and noted during the test.

1.2 Subject Selection

The experiment was performed with the participation of twelve subjects who are presently on active duty or are retired senior naval officers. The initial plan for the experiment was to have the assistance of twelve active duty naval officers who held the rank of Commander and above, but as we investigated the possibility of securing the services of active duty personnel, it was evident that it would be difficult to obtain the required number and caliber of active duty personnel to participate in the experiment. We approached the resident Naval Plant Representative (NAVPR), explained our need to have qualified senior active duty personnel to participate in the experiment and requested the services of any of the NAVPR who met our requirements. We gratefully acknowledge the cooperation and services of the active duty personnel who so willingly participated in this experiment.

For the remainder of our subjects we solicited the participation of nine retired naval officers who are presently employed by Grumman. These officers have a combined total of 219 years of active duty. They were delighted to have the opportunity to participate in the experiment and to share their experience to help in the decision aiding project.

Of the twelve subjects who participated in the experiment, seven were captains and five were commanders. They have a variety of naval backgrounds. All have at sea experience on operational staffs in a variety of capacities, including CARGRU staffs, and most have had command of a ship, including carriers with flags aboard.

1.3 Tattletail Scenario

The tattletail scenario chosen for the experiment is described within the context of the SRI developed ONRODA scenario, which is synopsized in paragraph 2.2 of this report. It assumes that there are two main forces in the proximity of ONRODA. A Red Force (hostile) located approximately 200 miles to the southwest of the island is composed of a Kresta class guided missile cruiser (CLGM) and five destroyer sized ships. The Kresta has a long range weapon (the SS-N-3 cruise missile) which can be brought to bear against the Blue (friendly) forces.

For the purposes of the experiment, it is assumed that RA-5C reconnaissance has revealed that the CLGM has detached from the remainder of the Red force and is proceeding on a course of 010 degrees.

The CTF has decided that the CLGM is a potential threat to the task force and has directed that one of the forces' ships be detached to acquire and surveil the Red ship. Five ships have been identified as being viable candidates to be dispatched to follow the threat ship. It is the task of the subject to select the best ship to detach to conduct the tattletail mission.

The Blue Force is composed of two Task Groups which have rendezvoused approximately 300 miles west of ONRODA to form Task Force 1. TF1 is composed of a total of 14 ships which range in size from Carriers (CV's) to Ocean Escorts (DE's) with varying degrees of value and weapon capability.

1.4 Test Scenarios

The tattletail scenario sets the general scene, introduces the subject to the forces involved and establishes the requirement for a tattletail. The test scenarios build on the developed scene and establish a framework for conducting the three parts of the experiment described in Paragraph 1.6.

To permit variation of the scenarios for each of the three test conditions comprising the experiment, four scenarios were generated and implemented during the experimental investigations. Each scenario uses the same basic type of data, i.e., graphics of the problem geometry and tabular data representing ships' status and capabilities for the tattletail mission (See Paragraph 1.7).

There are five candidate tattletail ships in each scenario. In some cases, the same ship may be in more than one scenario, but the ship's data has been changed.

One scenario was designed to be used solely for introducing the subject to the data available for conducting the test. This scenario is presented and explained to each subject, file by file, for the purpose of acquainting him with the information he can use in the course of the test to make his tattletail selection. No specific information as to the mission constraints is presented to the subject with this scenario.

The remaining three scenarios are designed so that any one can be used for any of the three test conditions which provide the varying levels of computer support. Each has a set of specific data which is comparable to an operations order and provides the subject with the conditions for the mission (e.g., allowable time to establish contact, fuel reserve requirements, area threats, etc.). There is a different group of tattletail candidate ships for each scenario. Where ships are used in more than one scenario, the ship's data which provides equipment fuel and ordnance status are changed.

Each of the scenarios is designed so that of the five candidate ships, it is relatively simple to eliminate two of them as not being able to meet one of the critical specific conditions required of the mission (e.g., the ship cannot intercept the Kresta within the specified time, the ship does not have the sufficient fuel to accomplish the planned mission, etc.). The remaining ships are then considered for their relative capabilities to perform the mission. This is done by evaluating the basic capability of each ship and the degradation in its capability due to CASREPTS (casualty reports) to the various equipments which are necessary for mission performance.

1.5 Command Support Simulator Operation

As a prelude to describing the specific graphic and alphanumeric data available to the test subject, the Command Support Simulator, where the actual experiments were conducted, is herein described.

The Command Support Simulator is a room approximately 20' x 20' with reduced lighting which simulates the Commander's area of a military command center, Figure 1-1. From the test subject's point of view, the simulator consists of two large Group View Displays (GVD's), two small CRT displays which flank two operator consoles, and a central control panel. Data is stored in a Varian V-73 computer and projected on the displays under control of an operator at the display buffer console of a Sanders ADDS900 Display Generator.

For the purposes of the Operational Decision Aids experiments, the capabilities of the Command Support Simulator were utilized to provide:

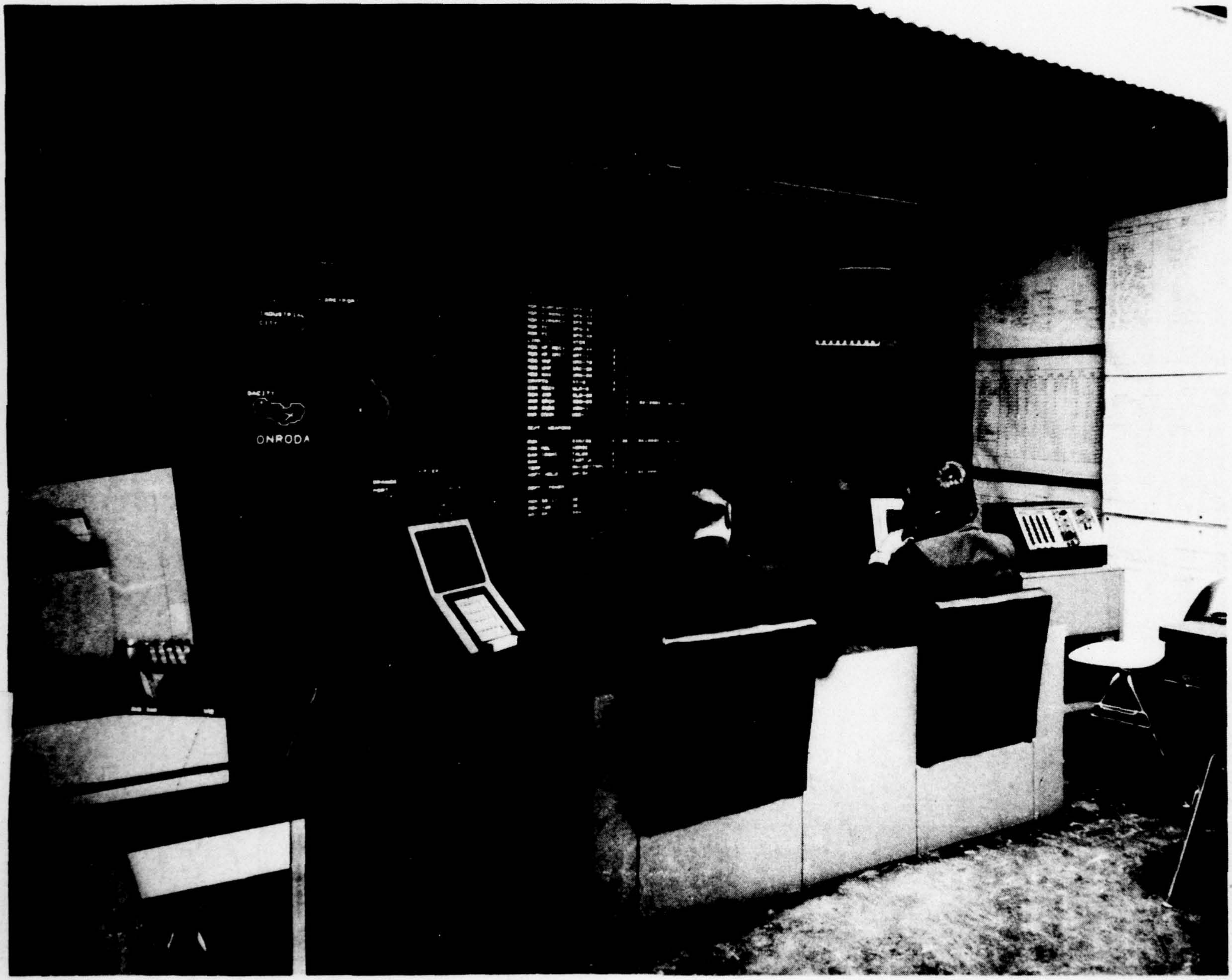


FIGURE 1-1 COMMAND SUPPORT SIMULATOR

- Graphic display of the tactical picture on the left hand GVD. The interactive capability of the system made available such features as graphic pan and zoom, and hooking of candidate tattletail tracks to provide intercept times and course to the ship to be tailed. In addition, this screen was used to display the options matrix.
- Tabular data files display on the right hand GVD. These displays present alphanumeric information of ship's status and capability as well as tabulated displays of calculated data for intercept times and fuel consumption.
- Small screen display of the data tables which prompt the subject to look at certain data in making his decision.

The operator normally displays the information as described above, but the subject can call for the data to be displayed on any combination of screens he desires.

1.6 Test Conditions

The tattletail experiment was designed to be conducted in three parts to permit evaluation of subject performance with and without the matrix, and to test for acceptance of the selection matrix as a decision aid.

In condition 1 of the experiment, data are presented to the subject in graphic and alphanumeric format on two group view displays (GVD's), and on hard copy data sheets. The graphic data is similar to the map, track and intercept displays available in the Interim Tactical Flag Command Center (ITFCC). It provides a map background of the ONRODA situation and the relative locations of underway Blue and Red forces. This display also provides locational and intercept data for the five tattletail candidate ships by showing the "present" location of these ships and the track each would take in order to intercept the threat ship as it proceeds along its expected track.

Alphanumeric information is presented as a series of ITFCC type data files which provide ships' status and capabilities data. Tabular displays of calculated data showing results of fuel and intercept calculations are supplied to

simulate the computational support available in the ITFCC.

Static data is available in the form of hard copy data sheets. This is data which would normally not be expected to change during the course of a deployment. Included are ships characteristics summaries, which provide ship's identification, physical configuration, sensor/weapon complement and propulsion equipment; weapon characteristics which provide launch, flight and effectiveness data; and tables of equipment performance data which provide capabilities of sensor and weapon systems.

During the test, the subject requests any of the graphic or tabular data he wishes to view. The operator at the Sanders display console calls up the data and it is displayed for the subject. The subject makes requests based on his judgement as to the most pertinent data and the best order for looking at the available information.

In condition 2, the subject is provided with two computer aids to assist him in choosing a tattletail candidate. The first is a prompt in the form of a list of the factors and sub-factors which are important to consider in making the tattletail selection. The second is a selection matrix into which he enters figures of merit (FOM) and weighting for the factors. Essentially, an FOM is the subject's estimate (on a scale of 0 to 10) of a ship's capability to perform one of the factors (e.g., acquisition) important to the selection of a tattletail, and weighting is his estimate (on a scale of 1 to 10) of the relative importance of a factor towards meeting the tattletail mission criteria.

The factors/sub-factors prompts are provided to aid the subject in establishing an orderly data search pattern. Use of these prompts enables him to make better use of the data than is possible under test condition 1. The subject calls for the data in accordance with the order of the sub-factors list, and is able to extract all the information required to fill in the selection matrix figures of merit with a minimum of interaction with the data base.

The selection matrix is the means by which the figures of merit obtained by the examination of the available data are recorded for use in making the

tattletail selections. As the subject selects a value for each of the figures of merit, he verbally requests that the operator enter the number into the matrix. When the figure of merit portion of the matrix is complete, the subject determines the weighting for each of the factors. He then makes a tattletail selection based on the weights and figures of merit he has chosen. A more complete discussion of the matrix, including sample figures, is provided in paragraph 1.8.

After the subject has indicated his selection, combinational algorithms developed as part of the school book solution are used to calculate the total figure of merit for each ship, based on the weights and figures of merit values assigned by the subject. Results are then compared with the school book solution. The school book solution also uses the subject's weighting factor inputs, but its figure of merit values are determined by algorithms designed to objectively combine factor and sub-factor information expected to be contained in a Command and Control System data base.

For condition 3 of the experiment, the subject is shown the selection matrix with the figures of merit filled in, based on the algorithms developed for the school book solution. He is asked to evaluate the figures of merit, to again review the available data as he has done in the other two conditions, and to change any figure of merit with which he disagrees. The subject inputs weighting factors as in condition 2. The combinational algorithm is then used to determine the total figure of merit and the subject is asked for his feelings about the school book solution. The object is to determine whether the subject is "comfortable" with a solution over which he merely has "after the fact" control, whether he will accept the school book solution, what areas of the matrix he is most likely to be "distrustful" of, etc.

1.7 Graphic and Tabular Data

In conducting the experiment, graphic data sufficient to provide the subject with the geometry of the situation is presented on the left hand GVD. Figure 1-1 shows a map of the ONRODA area on the left GVD. The console operator can pan and zoom the picture to show portions of the situation such as in Figure 1-2, which contains an enlargement of ONRODA Island and a portion of the Red Force. The location of the Blue Task Force and the Red Force may be shown, then the display zoomed (Figure 1-3) to show the five candidate ships, the

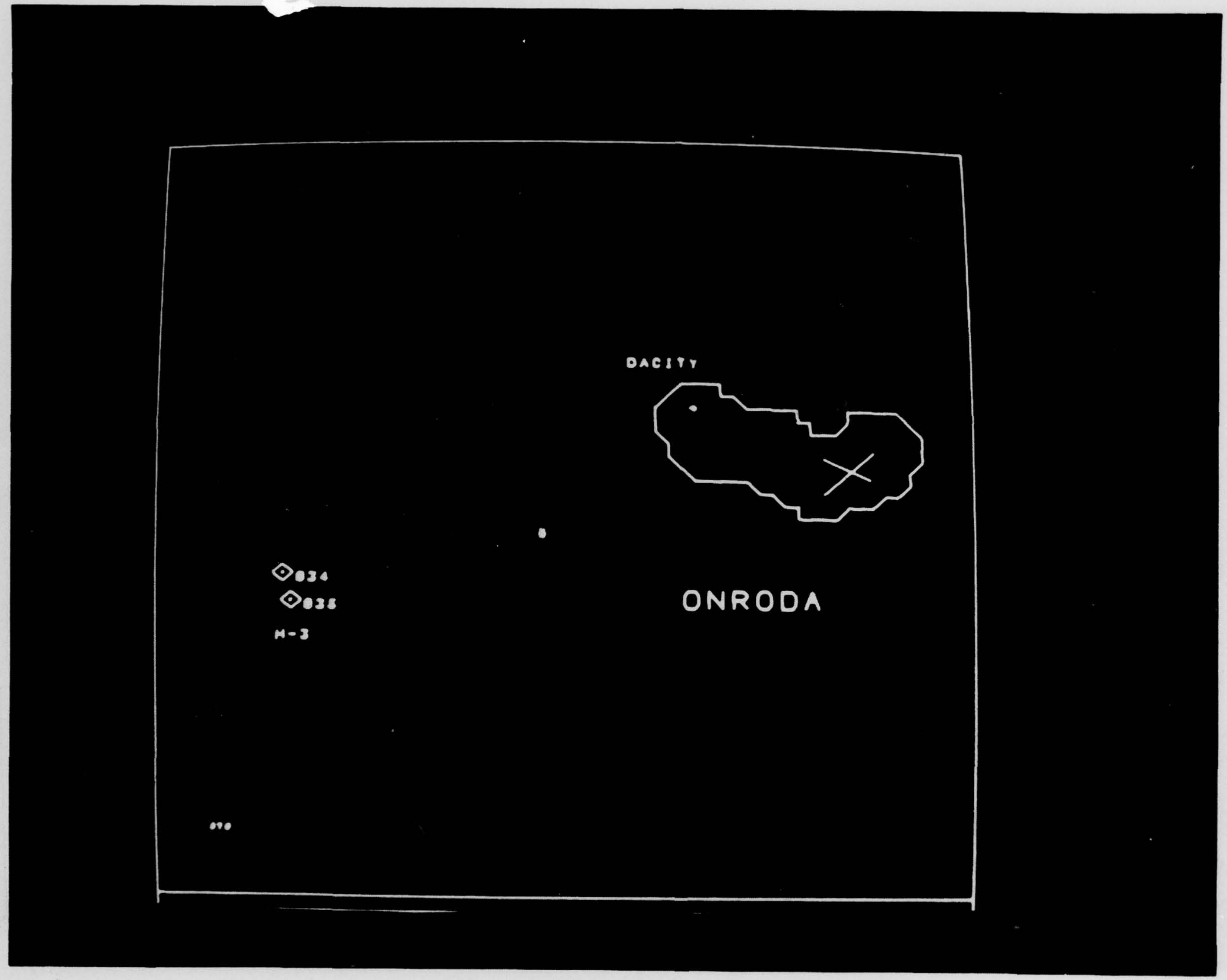


FIGURE 1-2 TYPICAL PAN AND ZOOM DISPLAY

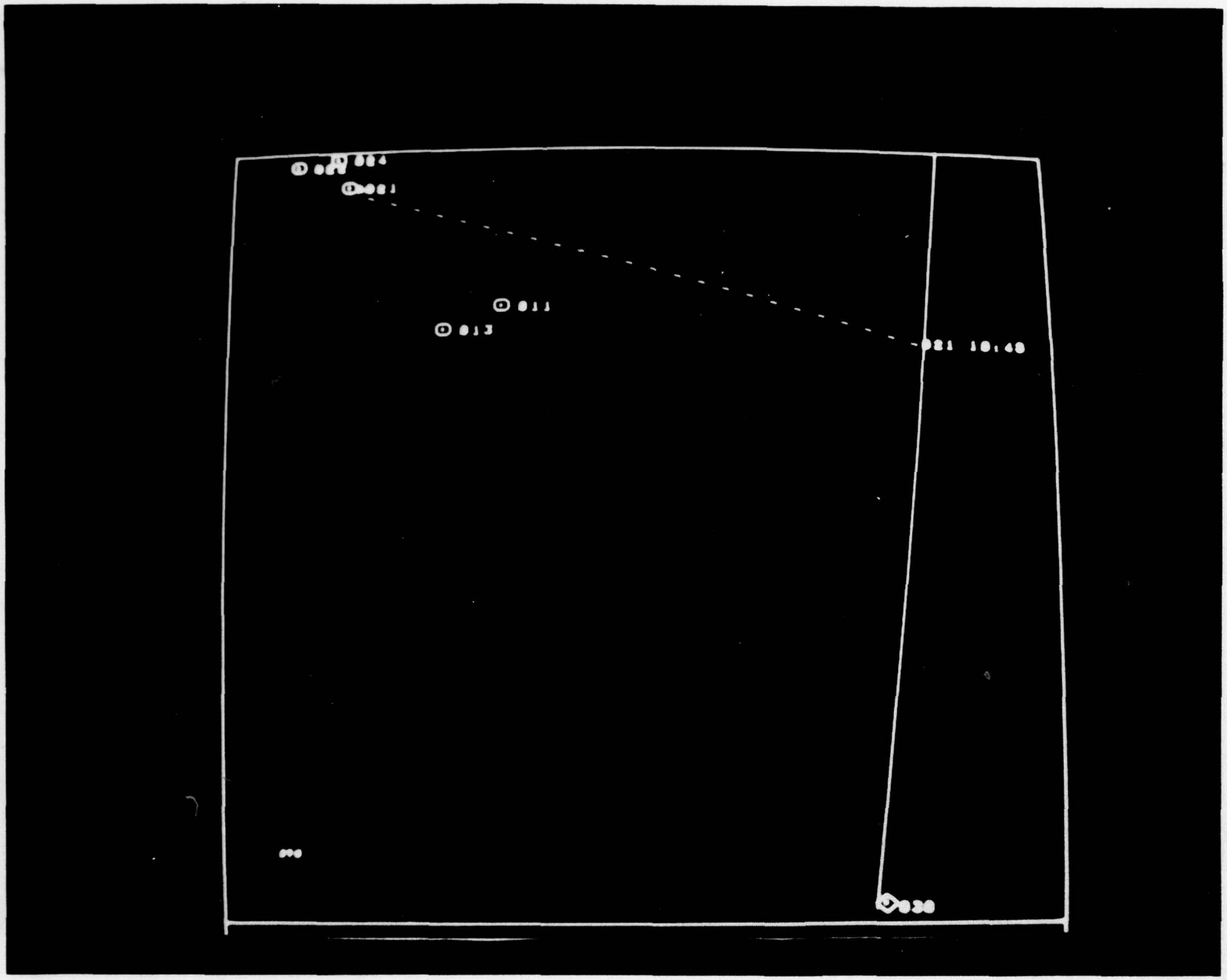


FIGURE 1-3 TYPICAL INTERCEPT GRAPHIC DISPLAY

assumed track of the threat ship and the intercept time and point of each ship along the threat's track. As this graphic data is presented, a tabular display on the right screen shows data pertinent to the graphics.

Representative samples of tabular data are shown in Figures 1-4 to 1-7. Formats for these data displays were chosen to be similar to the formats which are used in the ITFCC.

The Ships' Positions File (Track File) of Figure 1-4 shows the present positions of the ships which are in the Blue Task Force and in the opposing Red Force. For each ship the reference, hull, and track numbers are listed. The latitude and longitude of each ship, present course and speed, and source of the information are also listed. This data is presented in conjunction with the graphic display presentation which shows the location of the two forces.

The Equipment File (Figure 1-5) provides information on the equipment status for each ship. The file shows the ship's name, hull number and reference number. The equipments shown are those needed to perform a tattletail mission and are divided into electronics, weapons, and propulsion. For each of these equipment sets, the listing contains the equipment nomenclature and type, the number of systems of each kind, the status of each system (+ represents a fully operational system, 0 represents a fully down system, and a number represents the percentage capability of the system), the date-time that the casualty for each system which is not fully operational will be corrected, and a brief description of the nature of the casualty.

The CASREPTS File (Figure 1-6) is a summary listing of the ship's casualty reports. The equipment file shows the CASREPTS for each one of the ships listed as part of the overall ship's equipments. This file shows the casualties on each of the ships as a single listing and provides this data in a concise form. For each ship casualty, the department, nomenclature, and type of the down equipment is listed. The percent operation capability, the casualty correction time and the nature of the casualty of each down equipment is provided.

Minimum Time Intercept Calculation (Figure 1-7) provides the subject with a calculation of the time it will take each of the candidate ships, proceeding at maximum sustained speed, to intercept the threat ship. The data included in this display provides threat ship course and speed data, and a tabulation

SHIPS POSITIONS

NAME	REF	HULL NBR	TRK NBR	LOCATION LAT	LONG	SPD	CRS	SRCE	REMKS
KENNEDY	010	CVA-67	F-1	42 00'N	24 05'W	10	90	NTDS	
ALBANY	011	CG-10	F-1	42 10'N	23 50'W	10	90	NTDS	
TATTNALL	012	DDG-19	F-1	41 55'N	23 55'W	10	90	NTDS	
MULLINNIX	013	DD-944	F-1	42 05'N	24 20'W	10	90	NTDS	
HOLLISTER	014	DD-788	F-1	41 45'N	23 50'W	10	90	NTDS	
PAUL	015	DE-1080	F-1	42 15'N	24 05'W	10	90	NTDS	
VREELAND	016	DE-1068	F-1	41 50'N	24 15'W	10	90	NTDS	
INDEPENDENCE	020	CV-62	F-2	43 05'N	25 30'W	10	90	NTDS	
BIDDLE	022	CG-34	F-2	43 15'N	25 50'W	10	90	NTDS	
FOX	021	CG-26	F-2	43 05'N	25 15'W	10	90	NTDS	
HEWITT	023	DD-966	F-2	42 55'N	25 15'W	10	90	NTDS	
THOMAS	024	DD-764	F-2	43 20'N	25 20'W	10	90	NTDS	
ORLECK	025	DD-886	F-2	42 45'N	25 25'W	10	90	NTDS	
ROARK	026	DE-1053	F-2	42 55'N	25 35'W	10	90	NTDS	
KRESTA	030	CLGM	H-1	38 N	19 W	20	10	RA-5C	
KASHIN	031	DDG	H-2	39 N	20 W	18	355	RA-5C	
KOTLIN	032	DD	H-2	39 N	20 W	18	355	RA-5C	
SKORY	033	DD	H-2	39 N	20 W	18	355	RA-5C	
KASHIN	034	DDG	H-3	39 N	18 W	20	30	RA-5C	
KOTLIN	035	DD	H-3	39 N	18 W	20	30	RA-5C	

FIGURE 1-4 SHIPS POSITIONS FILE

NAME HEWITT NBR DD-966 REF 023

NOMEN	EQUIP TYPE	NBR	STAT	ETR	REMARKS
DEPT: OPELECT					
RDR SURFSRCH	SPS-10	1	+		
RDR AIRSRCH	SPS-40	1	+		
RDR FC	SPS-55	1	+		
LINK 11	NTDS	1	+		
RDO HF RECV	URR-75	2	+		
RDO HF XMIT	WRT-1	2	+		
RDO VHF	URC-70	2	50	310600Z	ALIGNMENT
RDO UHF	SRC-20	4	75	021200Z	PWR SUPPLY BLOWN
RDO HF	URC-32	2	+		
RDO NAV	UPN-12A	1	+		
CRYPTO	KY-14	2	+		
ESM RECV	WLR-6	1	+		
ECM JMR	SLQ-20	1	+		
SNR SRCH	SQS-26	1	+		
SNR VDS	SQS-35	1	+		
SNR SNDG	UQN-7	1	0	INDEFF	XDUCER WATER LEAK
SNR COMM	UQC-1	1	+		
DEPT: WEAPONS					
GUN	5IN/54	2	+		
GUN CIWS	VULCAN	2	+		
ASW MSL	ASROC	1	+		
ASMD MSL	SEASPARW	1	+		
ACFT LAMPS	SH-2D	1	0	301200Z	100 HR INSPECT
TORP	MK-32(TRPL)	2	+		
DEPT: POWER					
GEN 60 CY	WESTINGHSE	2	+		
GEN 400 CY	WESTINGHSE	2	+		
TURBINE	GE	4	+		

FIGURE 1-5 EQUIPMENT FILE

CASREPTS

NAME	DEPT	NOMEN	EQUIP TYPE	OPR CAP %	EST CASCOR	REMARKS
HEWITT	OPELECT	RDO VHF	URC-70	50	310600Z	ALIGNMENT
HEWITT	OPELECT	RDO UHF	SRC-20	75	021200Z	PWR SUPPLY BLOWN
HEWITT	OPELECT	SNR SNDG	UQN-7	0	INDEFF	XDUCER WATER LEAK
HEWITT	WEAPONS	ACFT LAMPS	SH-2D	0	301200Z	100 HR INSPECT
ORLECK	OPELECT	RDRAIRSRCH	SPS-40	0	061200Z	ANT DRIVE LEAK
ORLECK	OPELECT	SNR SRCH	SQS-23	0	021400Z	BEAM STEER UNIT
ORLECK	OPELECT	SNR COMM	UQC-1	50	310600Z	LOW OUTPUT
ORLECK	WEAPONS	TORP	MK-32	50	INDEFF	PNEUMATIC SEAL
TATTNALL	OPELECT	RDO UHF	SRC-20	75	011300Z	INOP TUNING
TATTNALL	OPELECT	RDO HF	URC-32	50	311000Z	PA REPLACE & ALIGN
TATTNALL	POWER	BOILER	CE	75	011800Z	FUEL INJECTOR REPLCE
THOMAS	OPELECT	RDRSURFSCH	SPS-10	0	310800Z	ANT SYNCHRO
THOMAS	OPELECT	RDO HF XMT	WRT-1	50	050800Z	REPLACE ANT CPLR
THOMAS	WEAPONS	TORP	MK-32	50	121200Z	L TORP ELEV MOTOR
THOMAS	POWER	GEN 400 CY	WEST	50	INDEFF	L DWN NEED SPARE
VREELAND	OPELECT	RDO HF RCV	URR-44	50	011800Z	PWR SUPPLY FLTRS
VREELAND	OPELECT	RDO UHF	SRC-20	67	020600Z	RELOCATING R/T
VREELAND	WEAPONS	ACFT LAMPS	SH-2D	0	062200Z	XMISSION HSING
VREELAND	POWER	GEN 400 CY	GE	50	311400Z	INSUFF STEAM
VREELAND	POWER	BOILER	B&W	50	311400Z	HI PRESS FLANGE LEAK SPD 18 KTS

FIGURE 1-6 CASREPTS FILE

MINIMUM TIME INTERCEPT CALCULATIONS *

TGT TRK= H1 KRESTA
- LAT 38 00'N
- LONG 19 00'W
- ESTIMATED SPD 15 KTS
- ESTIMATED COURSE 010 TRUE
- POSITION ERROR 8 NM

NAME	REF	TIME HR:MIN	SPD	CRS	FUEL CONSUMPTION	REMARKS
HEWITT	023	11:20	30	112	65,685	
URLECK	025	11:27	30	110	65,453	
TATTNALL	012	8:59	30	112	45,170	PROPULSION CASREP
THOMAS	024	11:42	30	115	66,929	
VREELAND	016	15:42	18	090	14,123	PROPULSION CASREP

* BASED ON PRESENT TRACK AND SHIP CHARACTERISTICS DATA

FIGURE 1-7 MINIMUM TIME INTERCEPT CALCULATIONS

of the candidate ships showing their speed, course to intercept and time to intercept. Fuel-consumption-to-intercept data is provided, along with a remarks column to show propulsion CASREPTS for ships with long intercept times.

Besides the data samples shown in Figures 1-4 to 1-7, tabular data files have been developed to present the subject with data on candidate ship's location, ammunition and fuel stores, candidate fuel consumption for various speeds used in the tattletail scenario, and candidate fuel consumption to perform the specified tattletail mission.

Four sets of tabular data have been developed for the experiment. Each set of data is basically the same, except that such things as CASREPTS, intercept calculation, and fuel quantities/consumptions are changed to make each scenario different.

1.8 Test Procedure

Prior to the test, each subject was briefed on the general background of the ONR Operational Decision Aid Program and on the nature of the tattletail experiment. The subject was given a set of documents to read in preparation for the test. These included a copy of the tattletail scenario derived from the SRI ONRODA scenario, a description of the tattletail's task, a general description of the conditions under which the experiment will be conducted, lists of the types of data which will be available to the subject, a description of the factors involved in choosing the best ship to send on the assignment, and a set of "hard copy" data. The latter is the type of data which normally does not change during the course of a mission and would usually be available to a commander in the form of manuals, tables, characteristic cards, etc.

The subject was requested to read the information package to acquaint himself with the overall situation, the conduct of the test and the data which is available for making a tattletail selection.

During the test, the subject was asked to occupy the CTF chair in the simulator (see Figure 1-1) from which he can view the two group view displays (GVD) and the small screen monitor displays. He was asked if he had questions about

the pre-test data. After answering any questions, the Test Conductor presented the sample scenario to the subject by having the console operator call the graphic and tabular data for display on the GVD's, and by explaining to the subject the information displayed by each graphic display or tabular file of data. This presentation acquainted the subject with the type of data which would be available to him for performing the tattletail selection and provided an opportunity to ask further questions if he did not understand any part of the presentation.

Following the presentation of the sample scenario, the subject was given the "Experiment Specific Conditions" data for the Condition 1 part of the experiment. This consists of two typewritten sheets of information which comprise the "operation order" for the experiment. The subject was asked to first read the specific conditions. He then could request a GVD display of the graphic or tabular formats which he considered pertinent to his tattletail selection for Condition 1. The experiment proceeded with essentially no time limits on the subject.

For the Condition 2 part of the experiment, the subject was introduced to the Tattletail Factors (Figure 1-8), which showed him the factors and subfactors important to the selection of a tattletail. It was explained that these factors should be considered in making the tattletail selection and to aid him. The files and elements of data to be considered for each factor were displayed as a prompt on the small screen display. This is illustrated in Figure 1-9 which for Surveillance Effectiveness shows the sub-factors the subject should consider and the data files to be examined for this data. This figure is a photo taken at the operator's console and shows the options selected by the operator with a light pen in conjunction with keyboard function keys, to call up matrix displays (SH-(X), total and A, B, C), tabular data (A/N-1 and 2), and graphics, and to select the screens on which the display is to appear (tube).

The subject was then shown a blank Tattletail Selection Matrix (Figure 1-10) on the left GVD, and it was explained that in this part of the experiment he would be asked to use this aid in making the tattletail selection. The method of filling in the Figures of Merit and the Weighting Factors was

TATTLETAIL FACTORS

THREAT ACQUISITION

-LOCATION OF UNITS/THREAT
-SPEED/ENDURANCE
-FUEL STATE
-UNITS ACQUISITION CAPABILITY
-THREAT CHARACTERISTICS

SURVEILLANCE EFFECTIVENESS

-ASSET/THREAT MAX SUST SPEED
-ASSET SENSOR CAPABILITY
-ASSET ENDURANCE
-COMM EQUIPMENT STATUS

NEUTRALIZATION

-ASSET WEAPONS
-WEAPON RANGES,FIRING RATE,ACCURACY
-AMMUNITION STORES

TATTLETAIL SURVIVABILITY

-THREAT WEAPONS
-WEAPON RANGES,FIRING RATE,ACCURACY
-ASSET DEFENSE COUNTERMEASURES

EFFECT ON TF DEFENSE

-ASSET SURVEILL/ATTACK CAPABILITY
-THREAT AIR,SURFACE,SUB-SURFACE

FIGURE 1-8 TATTLETAIL FACTORS

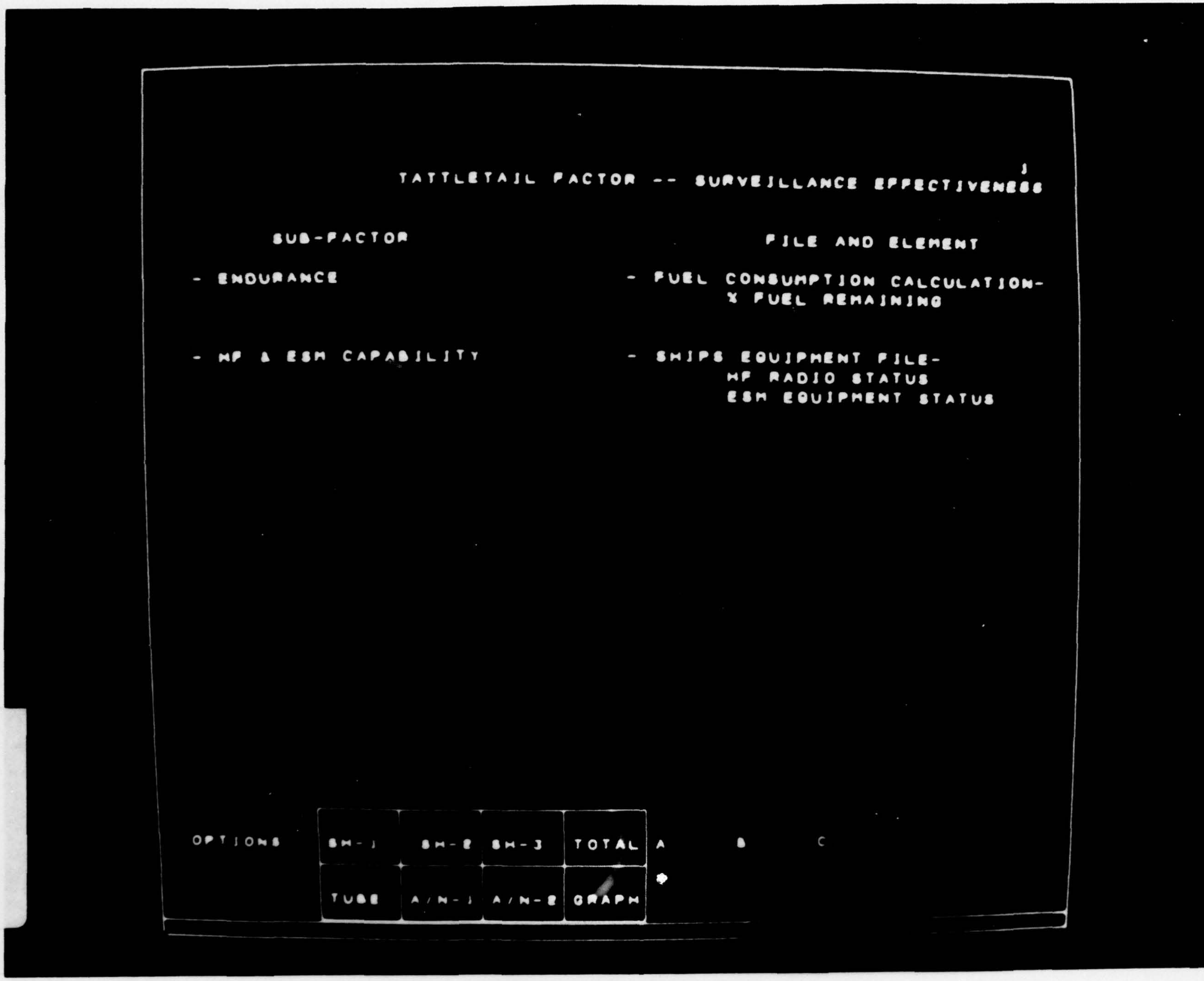


FIGURE 1-9 SURVEILLANCE EFFECTIVENESS PROMPT

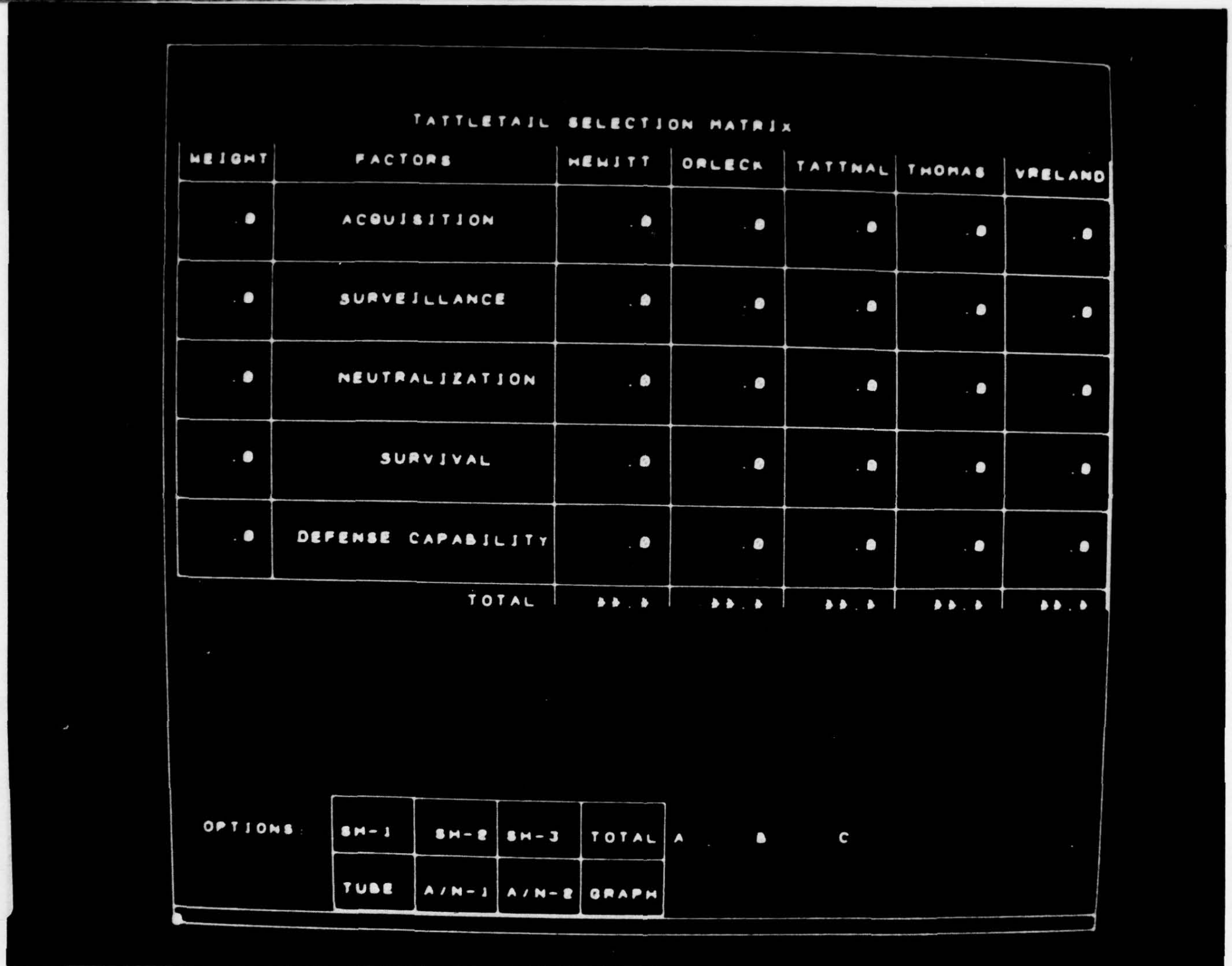


FIGURE 1-10 TATTLETAIL SELECTION MATRIX

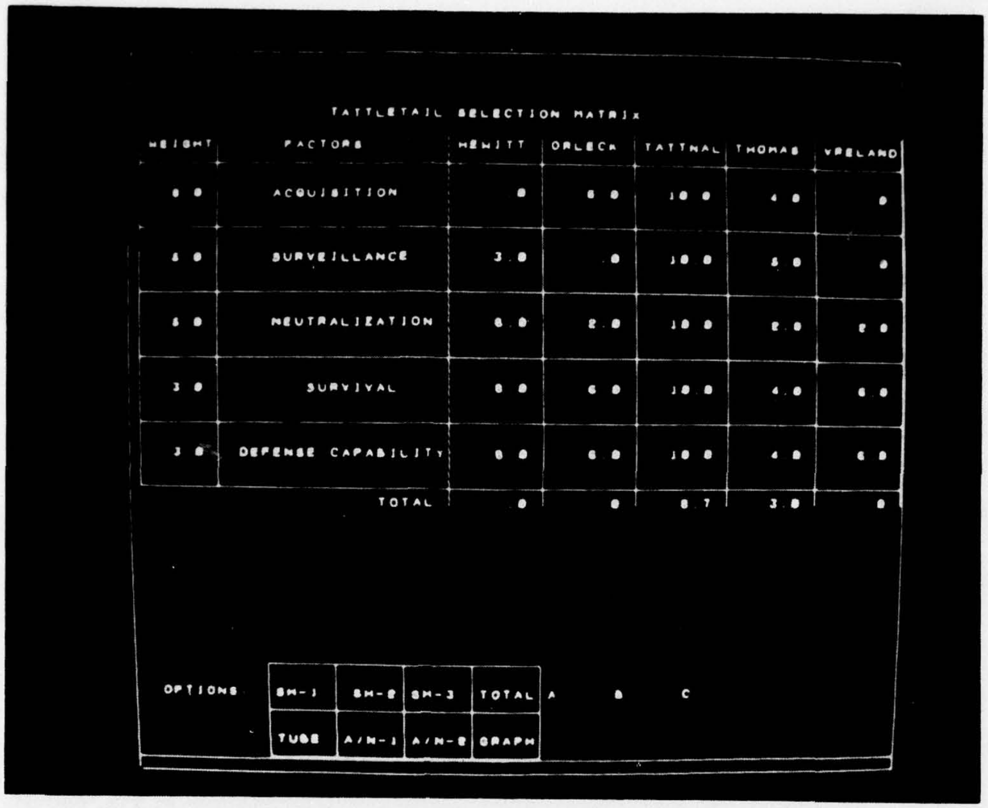
explained. The subject filled in the matrix in any order he chose. He could change his values at any time. A new set of "Experiment Specific Conditions" for this part of the test was given to the subject, and after reading it, he proceeded with the test. He requested graphic/tabular data displays and used the information to arrive at the figure of merit values to be entered in the matrix. Then, based on his knowledge of the situation, he determined the weights for each of the factors. The test conductor then had the subject inspect the filled-in matrix and, using the weights and figures of merit he had entered, determine the ship he would send as the tattletail. Figure 1-11 shows two "filled in" matrices. At the top is a typical subject's solution, at the bottom is the theoretically correct solution based on that subject's weighting factors.

After the subject made his choice of the tattletail, a combinational algorithm was used to determine the total figure of merit for each ship using the subject's weighting and figures of merit. His choice and that of the combinational algorithm were compared and discussed.

For the condition 3 of the experiment, the subject was shown a matrix already containing figures of merit and weights for each factor. It was explained that the figures of merit were obtained by employing a set of algorithms which take the various types of data (which were available to the subject in the graphic and tabular displays and in hard copy) and combine them to obtain the figure of merit, and that the weights were those he had selected in the previous part of the test.

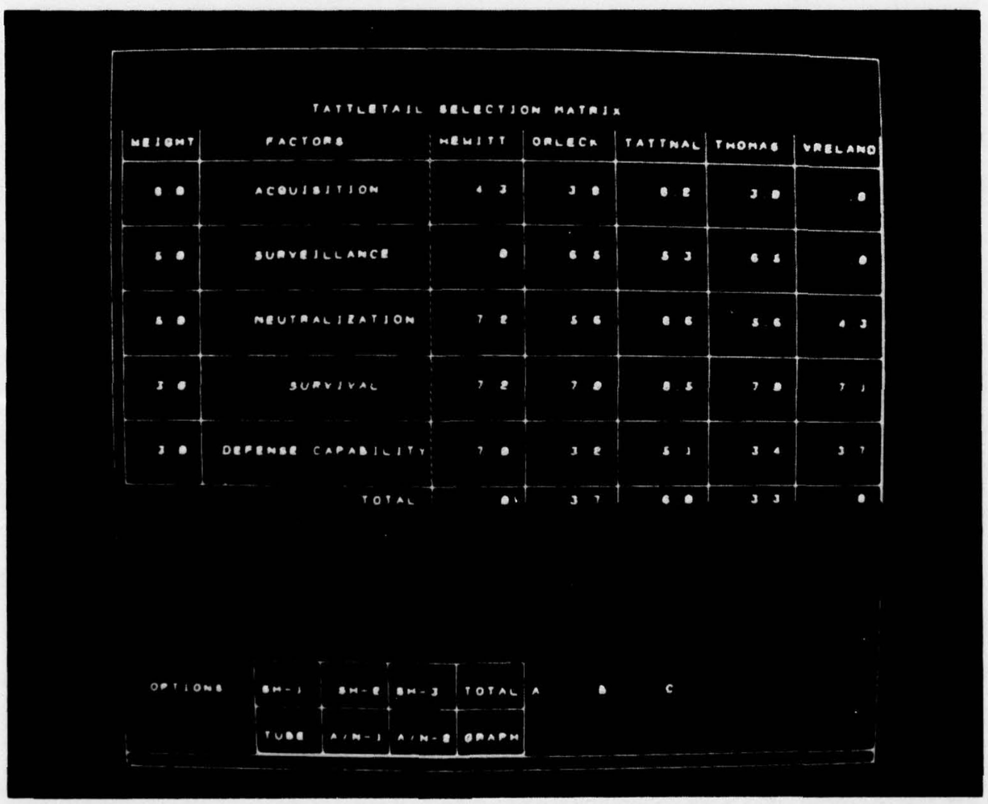
The combinational algorithm was used to show him the school book solution based on his selection of weights and the computer-generated figures of merit. The subject's feelings as to the acceptability of the school book solution were requested and discussed. Figure 1-12 shows the school book solution.

At this time, the subject was asked to comment on the three conditions of the experiment and was encouraged to use his knowledge of operational conditions to evaluate the use of the matrix as an operational tool. Emphasis was placed on determining subject acceptance of the decision aids.



TATTLETAIL SELECTION MATRIX

WEIGHT	FACTORS	HEWITT	ORLECK	TATTNAL	THOMAS	VRELAND
8.0	ACQUISITION	0	6.0	10.0	4.0	0
5.0	SURVEILLANCE	3.0	0	10.0	5.0	0
5.0	NEUTRALIZATION	8.0	2.0	10.0	2.0	2.0
3.0	SURVIVAL	8.0	6.0	10.0	4.0	6.0
3.0	DEFENSE CAPABILITY	8.0	6.0	10.0	4.0	6.0
	TOTAL	0	0	8.7	3.0	0



TATTLETAIL SELECTION MATRIX

WEIGHT	FACTORS	HEWITT	ORLECK	TATTNAL	THOMAS	VRELAND
8.0	ACQUISITION	4.3	3.0	8.2	3.0	0
5.0	SURVEILLANCE	0	6.5	5.3	6.5	0
5.0	NEUTRALIZATION	7.2	5.6	8.6	5.6	4.3
3.0	SURVIVAL	7.2	7.0	8.5	7.0	7.1
3.0	DEFENSE CAPABILITY	7.0	3.2	5.1	3.4	3.7
	TOTAL	0	3.7	6.0	3.3	0

FIGURE 1-11 TYPICAL MATRICES

TATTLETAIL SELECTION MATRIX

WEIGHT	FACTORS	HEWITT	ORLECK	TATTNAL	THOMAS	VRELAND
10.0	ACQUISITION	4.3	3.8	8.2	3.0	.0
9.0	SURVEILLANCE	.0	6.5	5.3	6.5	.0
6.0	NEUTRALIZATION	7.2	5.6	8.6	5.6	4.3
5.0	SURVIVAL	7.8	7.0	8.5	7.0	7.1
6.0	DEFENSE CAPABILITY	7.0	3.2	5.1	3.4	3.7
	TOTAL	.0	4.0	5.9	3.5	.0

OPTIONS							
	SM-1	SM-2	SM-3	TOTAL	A	B	C
	TUBE	A/N-1	A/N-2	GRAPH			

FIGURE 1-12 MATRIX WITH SCHOOL BOOK SOLUTION

1.9 Test Data Collection

The primary means for collecting data during the experiment was by means of a voice tape recorder situated in the test area to record all conversation during the course of the test. Subjects were encouraged to "think out loud" to provide a verbal record of the test, and tapes were generated which provided information of test elapsed time, data files called, time spent on each file, and subject's comments.

The test elapsed time was recorded to provide a record of the times when events occurred in the course of the test. Events such as elimination of a ship from tattletail consideration, at what point during the test significant remarks were made, and the time taken to arrive at tattletail ship selection were of interest in evaluating the experiment.

The data files called and the time spent on each file provided information on the subject's methodology in arriving at a selection. Recording file call up permitted the examination of the order in which files were called, the type of files called and the number of times the subject looked at the same file. These file calls were then evaluated with the subject's comments.

Subject's comments during the test provided an overall insight into his performance. Comments gave an idea of the subject's understanding of the experiment, his grasp of the data presented to him, his feelings for the experiment and his acceptance of the decision aid.

1.10 Test Results

The test subjects who participated in this experiment are representative of the people who would be expected to be involved in operational decision making and using aids such as the options matrix. In conducting the test we recorded data as explained in paragraph 1.9, however we are less interested in the quantitative data obtained than we are in the qualitative comments the subjects had as to the operational potential of the options matrix.

Prior to the test, each subject was asked to comment on the descriptive material he had been given to prepare him for the test. All agreed that the material gave them a good understanding of what the test was about and of the background information pertaining to the scenario.

There were no time constraints imposed on the subject to accomplish the tattletail selection for the three conditions of the experiment or to discuss any aspects of experiment on which he cared to comment. Subjects varied in their willingness to comment and to share their experiences, but to a large extent they tended to enjoy the opportunity to discuss their experiences related to data availability to the commander, display of the data and the ability of the commander to make intelligent decisions from the available data. They used these experiences in commenting on data formats in the experiment, the use of the options matrix and the mechanics of presenting the options matrix.

The subjects' experience in some cases caused them to be predisposed to ignore the ground rules imposed as part of the experiment and to use their own judgement as to what the ground rules should be. For example, a ground rule states that the candidate ship must be capable of intercepting the track of the threat ship within a period of 12 hours, and the Intercept Calculation shows the time to intercept for each of the five candidate ships. This data file shows that because of initial position and speed capability one of the ships will take longer than the required 12 hours to accomplish the intercept. Several subjects questioned the validity of the imposition of a time constraint of this nature and considered that it would not be the type of constraint to be used in an actual situation. It was explained that this time constraint was used to help bound the problem in order to allow the subject the ability to solve the problem in a simulated environment and that we fully realized that some of the constraints imposed on him in the experiment were artificial but were done to facilitate arrival at a solution.

After completing the condition 1 and condition 2 parts of the experiment, each subject was asked to give his thoughts about each part and then to compare the two parts.

After completing the condition 1 and 2 parts of the experiment each subject was given the school book solution for the best tattletail choice and why that ship should be chosen. He was asked to comment on his, versus school book choices and to give his thoughts about each of the two parts of the experiment.

For these two conditions, the choices of tattletail ships were:

	Condition 1	Condition 2
Correct choice	5	8
Possible, not best choice	6	3
Incorrect choice	1	1

The experiment was designed so that for each scenario there are two or three seemingly best tattletail choices. Use of the matrix helped the subjects to make the correct choice more often, and subjects who had made other than correct choices tended to agree with the school book solutions.

Several commented that the tabular data presented in condition 1 contained too much information, most of which was not pertinent to solving the problem. In addition, the data pertaining to the equipment aboard each ship would have been easier to read if it were presented according to equipment type and in such a manner that the same equipment types on ships could be compared against each other. It was explained that the data as it was presented is essentially the way it appears in a system presently being configured for a command support center. Their comments were certainly valid and it would be beneficial to obtain equipment status data in such a manner that ships' capabilities could be compared against each other. Another recommendation related to data presentation was to show only the data pertinent to any of the specific tattletail factors under considration. For instance, in considering Surveillance Effectiveness, the prompt instructs the subject to look at:

- Candidate ship's maximum speed and the threat's maximum speed
- Fuel consumption calculation for percent fuel remaining after the mission
- HF radio status in the Ship's Equipment File
- ESM equipment status in the Ship's Equipment File.

For the first two items on this list, the data for each of the ships is shown as a single display, but for the third and fourth items the subject must look through the equipment file for each of the ships.

The subjects felt that, rather than show the complete equipment file, if the operator could query the file to provide only the HF or ESM equipment status for each of the candidate ships, it would be easier to compare the ships against each other for their capabilities.

The subjects realized that in doing the condition 1 part of the experiment they could look at the available data in any order they desired, but that in the condition 2 part of the experiment they were prompted to look at certain data in a predetermined order, (as shown above for the Surveillance Effectiveness factor). They commented that the use of the matrix with the prompts to help enter figures of merit into the matrix was a more rigorous approach to obtaining the best candidate ship. They felt that the matrix was cumbersome to work with in the beginning, but as they progressed in filling in the matrix they were able to obtain a certain amount of familiarity with the procedure needed to make figure of merit selections and were able to furnish these numbers with more ease and confidence.

The average time to complete the condition 1 part of the experiment was 14 minutes, 25 seconds and for condition 2 the time was 32 minutes, 30 seconds. Subjects took more than twice as long to complete the experiment while making use of the matrix. This time can be looked at in conjunction with the number of files the subjects called which were an average of 8 files for condition 1 and 12 files for condition 2. The subjects looked at each file in condition 1 for an average of 1 minute 48 seconds and in condition 2 for 2 minutes 42 seconds.

They knew that it took a longer time to fill in the matrix and arrive at a ship selection for the mission, however most felt that their selection in condition 2 was based on a more thorough evaluation of the available data and were more confident in their decision. Subjects expressed the opinion that with the continued use of an aid like the matrix a facility would be gained for working with it, so that the time required to reach a decision would be comparable to that without the use of the aid. More importantly, they would be more confident in the decision being correct because of the use of the matrix.

Two subjects expressed the opinion that they would prefer not to work with a "full"matrix i.e., to fill in figures of merit for all the ships under consideration and then to use the matrix figure of merit selection to make the choice between two or three ships. In effect, most subjects did this during the course of the experiment, in that when they decided that one or more ships would not meet the criteria set forth in the ground rules, they gave those ships figures of merit of zero for all the factors and disregarded those ships in making their final tattletail selection. One subject commented "having a gut feel for the capabilities of the ships in the force is good, but it helps to have this backed up by numbers in something like a matrix."

The above comments are in relation to the subject's filling in the figures of merit into the matrix by himself. We then proceeded to condition 3 of the experiment, in which subjects were shown a matrix into which figures of merit had been inserted. It was explained that the figures of merit appearing in the matrix were calculated using an algorithm for each factor which took into consideration a limited set of the same computer generated and hard copy data which the subject had available to him during the condition 1 and 2 tests. Information had been extracted from the data sets and inserted into the algorithms to yield the figures of merit shown. Subjects were asked for comments on their views of having a computer supplied solution. This evoked many comments from the subjects.

An initial reaction from most subjects was to question if the figures of merit entered in the cells of the matrix could be changed or if they were final. It was explained that the subject was free to look at the data again and could change any of the figures of merit which he considered to be incorrect for any reason and that total figures of merit would be recalculated.

Subjects showed interest in how the algorithms were generated and what were the parameters considered in order to arrive at the algorithm. Before accepting the algorithm most felt that they would want to be able to understand the algorithms and insure themselves that the algorithms took into account a sufficient set of data to adequately cover the parameters of the problems. They felt that the algorithms could take into account more information and more precisely operate on it than they could and would represent a great advantage if the algorithms could be trusted.

This led to discussions of how the algorithms would be generated, and it was generally accepted that they would probably be initially generated by a group such as the Command Support Systems Group. They would then be reviewed and modified by the members of the CTF staff to insure that they included all parameters which both groups considered to be important.

However, this did not lead to full acceptance of the matrix figures of merit and the calculated tattletail ship selection. Most subjects felt that they would question the individual figures of merit which they considered to be too high or too low and would want to see a justification for the number. They also would not necessarily accept the ship with the highest total figure of merit, but would reserve the right to apply their own "gut feel" to the final ship selection. The feelings of most subjects were to a greater or lesser extent summed by the subject who stated "I wouldn't allow the computer to make the judgement for me".

Subjects differed on their trust of numbers in the matrix. At opposite ends of acceptance were two subjects; one, an engineer stated, "I like numbers and have faith in them", the other stated, "I don't think what you put up there (in the matrix) is the answer".

Another point brought up with regard to the algorithms concerned the ability to introduce into the equations factors to account for specific situations as they arise in the course of planning for the mission. This would include things such as abnormal weather conditions and new types of enemy weapons. Admittedly, the matrix figures of merit would have to be considered in light of these factors and the individual figures of merit changed to account for these factors. This consideration would also apply to the weighting of factors internal to the algorithm which provide weights to weapons capabilities, ships' worth, type warfare expected, etc.

"The matrix takes everything into account; I couldn't do that" is the way one subject described the matrix. Other subjects expressed similar opinions and they were aware that even when using the prompts of condition 2 to lead them to the correct data to use for the figures of merit, they were not able to integrate the data mentally to arrive at a mathematical figure of merit as the algorithms do. This led to the conclusion reached by all subjects and expressed in various ways, but summed up by the comment of one subject, "The matrix could be a tremendous asset for evaluative work."

The subjects agreed that the evaluation of the situation and the manipulation of data in the matrix is the type of effort which would be done by staff members and the CTF would make a decision after review of the data. Most subjects felt that the CTF would probably not be satisfied with simply looking at a completed matrix and allowing the matrix results provide him with the solution. He would probably want to see the data that was used to obtain the figures of merit, and the staff would have to be prepared to justify these numbers. However, one of the subjects thought that as a commander he would be inclined to accept the work of the staff members in obtaining a solution by the use of the matrix, saying, "I wouldn't have them on my staff if I didn't trust them." Comments of the subjects indicate that the use of the matrix as a decision tool would depend on the trust the commander has in his staff and the trust the staff has in the ability of algorithms to provide sufficiently accurate and complete data for filling in the matrix.

1.11 Conclusions

Our efforts to date have been to conduct experiments to evaluate the ability of a subject to use an options selection matrix for making a decision. Twelve subjects with operational experience have been tested in the Command Support Simulator to determine their ability to make a decision in employing a specific aid and to elicit their comments as to the operational potential of the options matrix decision aid.

The experimental testing shows that using the matrix and set of prompts to help the subject look for data pertinent to the portion which he is assessing is a rigorous and initially somewhat cumbersome process. However, after using the matrix, an amount of familiarity with the procedure is reached and there is an ease in using the aid and confidence in the decision reached. Subjects expressed the opinion that with practice the options matrix could become a useful tool for ship selection decisions.

Subjects did not accept the use of a matrix filled in by a set of algorithms, with the solution of the best ship for the mission displayed as an "automatic" solution. They felt that in some way, to a greater or lesser extent, anyone working with the matrix would want to understand the algorithms used in the matrix and be able to manipulate the inputs into the algorithms and change the

algorithms to obtain confidence in the outputs provided by the matrix. A possible approach to accomplish this would be implemented by presenting the matrix in three parts.

- Factors for which a definite mathematical answer can be determined, such as acquisition and surveillance capability would have calculated figures of merit filled in by algorithms.
- Factors for which a mathematical solution is only partially acceptable, such as neutralization and survivability, because of the number of variables involved, should have partial solutions derived and presented. These can be examined along with other data to arrive at revised figures of merit.
- Lastly, for factors which are purely subjective and have no mathematical solution, e.g., commander preferences, the matrix will allow for entry of figures of merit by the commander.

In summary, the subjects expressed the opinion that to use the matrix the commander would require trust. This would be initially required of the system analysts who determine the parameters and the equations used for obtaining the figures of merit. Then he would have to trust the operators who supply the input data into the algorithms, that this data reflects the situation and is properly inserted into the equations. He would have to trust his staff that the selections made by the use of the matrix are indeed the best selections to make and reflect the best choice after consideration of all data available.

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2 - INVESTIGATION OF OTHER DISPLAY FORMATS

2.1 Introduction

In this section two other decision problems are chosen to provide a framework for developing other data display formats than those used in the Tattletail Selection Problem. The two decision problems are:

- Selection of the best operating area for the Task Force to conduct a specific mission
- Selection of the best transit route for the Task Force to reach the selected operating area.

A sequence of interactive graphic and alphanumeric displays are described that could be used by the Task Force Commander and his staff to assist them in arriving at a solution to the two aforementioned decision problems.

First, a synopsis of the ONRODA scenario as it applies to the two decision points is presented. Next the Ops Area and Transit Route Selection problems are explained in more detail, including a summary of the major data display formats that are used during the decision making process. Following that is a description of how a user would interface with the computer to enter data, call up data displays, respond to queries and, in general, utilize the capabilities available to him. Next, examples which illustrate in step-by-step fashion how the decision aiding capability would be employed, first to solve the Ops Area Selection problem and then the Transit Route Selection problem, is presented. A proposed experiment to test the efficiency and user acceptance of these data display sequences is then briefly discussed. The section ends with concluding remarks and recommendations for future work.

2.2 ONRODA Scenario Synopsis

The analytic effort reported herein was conducted within the context of the ONRODA Warfare Scenario described in SRI Research Memorandum NWRC-RM-83. The following short synopsis of the ONRODA scenario is presented here to introduce the situation and provide a background for the discussion of the two decision points to be addressed.

Concurrent with the emergence of nationalism in the ONRODA Bay littoral commencing some thirty years ago, the peoples of the area have been exposed in varying degrees to the influence of foreign ideologies and politico-economic pressures. The ultimate result has been that some factions in each emerging country (ultimately Grey, Yellow and Orange nations) have fallen under the influence of Red, and others under that of Blue. Although the trend in each has been toward stronger national government, the ideological alignments at the local level have sometimes been inconsistent with the posture of the national government.

At the level of national government, Grey is aligned with Blue, Orange with Red, and Yellow is weakly aligned with Orange and Red.

Grey and Orange have been ideologically opposed and hostile to each other for years.

The population of ONRODA Island, the government of which has traditionally been politically aligned with Grey, has a significant segment of Orange sympathizers. This minority has, within the past year, sent delegations to Orange alleging discriminatory treatment and requesting support from Orange for their cause.

Commencing with a program of terrorism instigated by a few dissident local leaders, with moral, economic, and propaganda support from Orange and Red sources, a rebel organization known as "Greyhawks" has evolved within Grey nation over the past eight years. During the past year this organization has been able to mount an armed revolt against the Grey government, with successes including the capture of a major city in Grey two months ago, and the acquisition of military control over the areas of Grey nation shown on the area chart (See Figure 2-3). The Greyhawks have sought and received increasing support from Orange, including military experts, training, small arms, mortars, and rockets. Materiel has been delivered from Orange by air, water and overland through Yellow (with Yellow's passive cooperation).

As a result of Grey's diminished military capability and preoccupation with the suppression of the Greyhawk rebellion, Orange, using the pretext of

relief for the "exploited" ONRODA minority, attacked the Grey forces on ONRODA Island on 31 December. By nightfall, the Island was held by Orange forces. The Orange incursion onto ONRODA was complete with the introduction of SAMs, Anti-aircraft guns, and construction equipment on the day the island was seized. Grey's counter-action to the ONRODA landing by Orange, which was in the form of air strike from Grey mainland, was too late to preclude the establishment of an effective air defense of the island by Orange forces. Orange immediately began construction efforts to enhance the military capability of the existing civilian airport on ONRODA.

Grey filed an immediate (31 December) urgent protest to the UN Security Council requesting intercession in her behalf, and similarly appealed to Blue for unilateral assistance. Blue political analysts' evaluation was that the UN would not take any timely effective action. Furthermore, it was deemed unlikely that Blue Congress would act on the Grey request in less than several weeks. That Blue President would order direct intervention in the absence of a Congressional mandate was considered doubtful at this time.

A Blue carrier Task Force has been formed and has been given the mission: "When directed, begin operations to neutralize Orange forces and facilities on ONRODA Island in order to defend Grey. Do not attack targets on Orange mainland or in Orange ports. Take defensive measures to protect your force from Orange or Red retaliations."

As a result of increased Orange and Grey military activity in November and December, Blue increased her forces in the area so that on the morning of 31 December one carrier group (CARGRU-ONE) was conducting training exercises about 400 miles west of Mid-Ocean Island and another carrier group (CARGRU-TWO) was in various liberty ports about 1500 miles from ONRODA Island.

On the evening of 31 December COMBLUFLT directed COMCARGRU-ONE to position CARGRU-ONE within strike distance of ONRODA Island and the Grey coast but to remain well out of the Red training area.

The impending movement of CARGRU-ONE in response to this directive constitutes a two-fold decision problem to COMCARGRU-ONE and his staff:

- Selection of the optimum operating area within striking distance of ONRODA Island consistent with current directives and the existing situation.
- Utilizing the best available and postulated information, selection of the optimum transit route for the movement to the objective area.

2.3 Operations Area Selection

The Decision aiding displays envisioned for assistance of the Task Force Commander and his Staff in the selection of an operating area comprises an interactive system of graphic and alphanumeric displays of data which assists them in quantizing the component factors associated with the decision problem, each as a function of position, and in ordering their relative import. These factors are:

- Vulnerability/Effectiveness Summary
  - Weapon Systems Effectiveness
  - Vulnerability
    - Air Threat
    - Surface Threat
    - Sub-Surface Threat
- Logistic Support
- Operating Constraints
- Aircraft Route Planning

Figure 2-1 is a depiction of the process by which these factors are used in operations area selection, and Figures 2-3 to 2-28 illustrate the use of these factors to display an example of ops area selection.

The analysis of COMCARGRU ONE and his staff leading to the selection of an operating area is predicated on the assumption that the most effective means available to accomplish his mission is to exploit his air strike capability, either as an immediate threat or, when directed, in projected operations against Orange forces and installations on ONRODA Island. Consequently, the selection

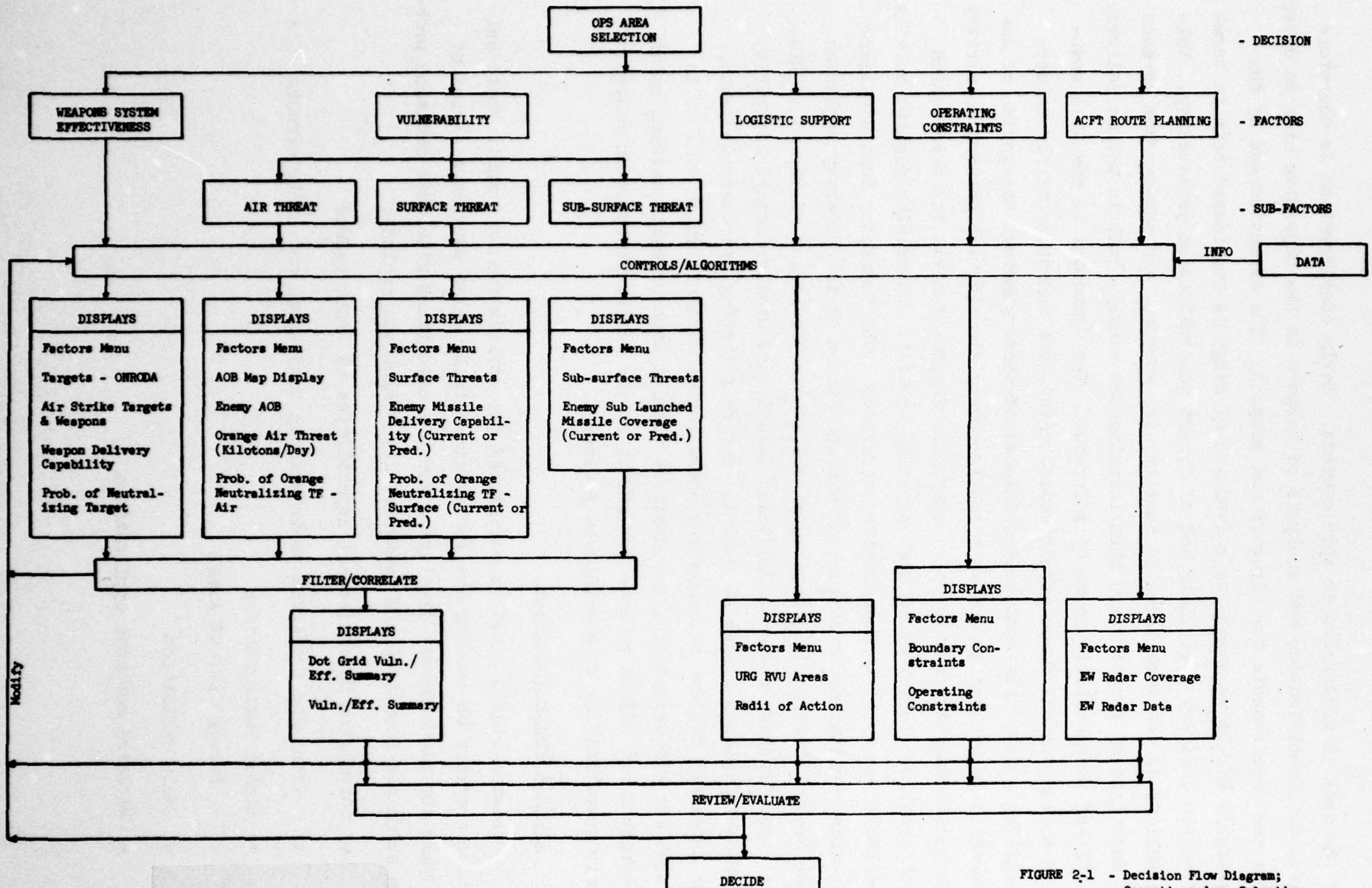


FIGURE 2-1 - Decision Flow Diagram; Operations Area Selection

of the area is undertaken in this context. Early consideration is therefore given to identification and analysis of targets in the objective area to determine the requirements for aircraft and weapons. The effectiveness of the available offensive assets as a function of range is considered both in terms of weapon delivery capability and of target neutralization probability. Vulnerability of the Task Force to hostile air, surface, and sub-surface threats as functions of position are then investigated singly, both in weapon delivery units and probabilistic terms of reference. The Commander is now in a position to compare his force effectiveness versus the summation of his vulnerabilities. An overly-complicated display of these numerous categories of information is avoided by use of a dot frequency distribution pattern to portray the positional distribution of a composite figure-of-merit for association with candidate locations in the operating theater. Underlying digital data is available for specific quantitative reference. The Commander next considers the areas available for support of his operations by the Underway Replenishment Group. Pertinent to this consideration is the radius of action of Blue Air Force fighters based at Mid-Ocean Island, and similar escort capability of MIG-21 fighters stages at ONRODA. Before selecting his operation area, the Commander reviews the existing operating constraints which will be in effect for his operations, and examines intelligence of early warning radar coverage about ONRODA to note its effect on air strike penetration routes and their compatibility with candidate positions.

2.4 Transit Route Selection

Decision aiding displays envisioned for utilization in transit route selection comprise an interactive system of controls which provide a series of graphic and alphanumeric displays. Factors associated with this decision problem which are quantized and presented for evaluation include:

- Stipulated time/distance capabilities of track assets
- Current and predicted environmental conditions and their effects
- Threat vulnerability
  - Average threat level
- Route definition
- Relative movement applications

The process by which these factors are utilized in transit route selection is shown in Figure 2-2.

Ths displays associated with quantization of effectiveness and vulnerability and consideration of logistic support and operating constraints which were demonstrated for use in selection of the operation area are also available for call-up in this application.

In the example considered for the ONRODA scenario and illustrated in Figures 2-29 to 2-46, the question of route selection for the carrier Task Force to the selected operating position is treated after selection of an operations area. Initially, the curves representing furthest-on positions for 12 hour intervals at a selected 30 knot SOA are displayed. It is desirable that the hostile commanders know that the Task Force is moving and that the transit will constitute a threat to Orange forces on ONRODA, but not to the Red Task Force. By reference to the predicted synoptic weather chart the Commander ensures that weather will be no problem during the transit and that whatever enemy surveillance efforts are active in the area will not be thwarted in detection of his movement. To establish in his mind when the Red/Orange Commanders will certainly be apprised of his movement, he refers to the display of current/predicted transits of the Red surveillance satellite COSMOS 777. It appears that his movement will be duly noted by the 020947Z transit slightly North of Mid-Ocean Island. Reference is now made to the distribution of the composite threat vulnerability in the operating theater. The operator having previously established that the primary threat to the Task Force at the selected operating position is the air threat from the direction of ONRODA Island, an intermediate transit point is designated to minimize the vulnerability to this threat during final approach to the operating position. Another intermediate transit point is selected to clear North Cape on Mid-Ocean Island by 50 N Mi, and a third is established as a loiter point for conduct of local operations en route. The most direct route is generated as defined by these points. The total distance is calculated and displayed to be 1320 N Mi. The distribution of hostile threat level along the tentative track is ascertained.

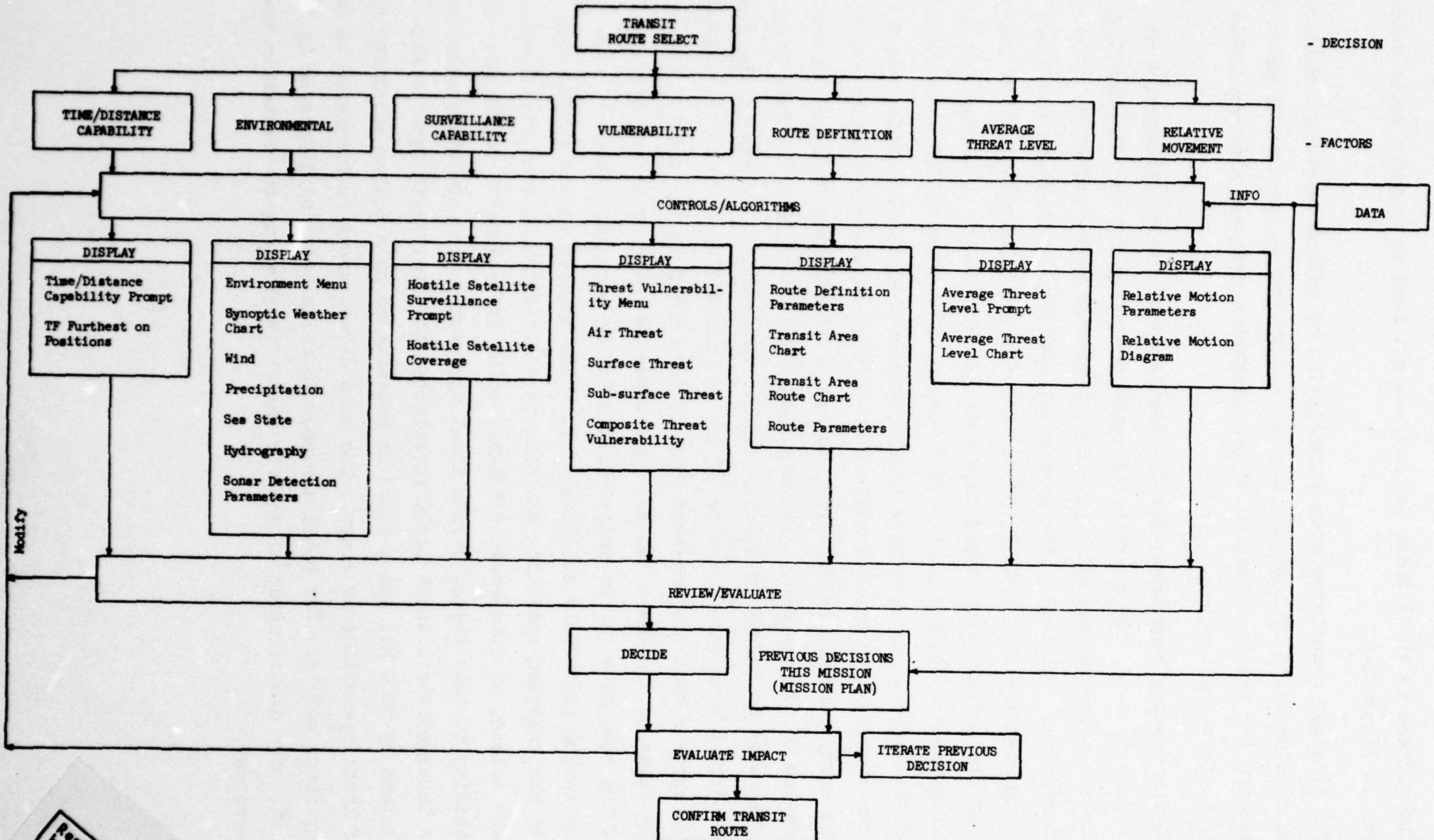


FIGURE 2-2 - Decision Flow Diagram; Transit Route Selection

A significant perturbation of the Transit Route Selection problem is occasioned by receipt of intelligence apprising the Task Group Commander of the establishment of an Orange submarine patrol area to the Eastward of Mid-Ocean Island. The immediate effects of this information are two-fold. First, of course, it fills the blank portion of the available intelligence concerning the whereabouts and employment of the one Orange operational submarine. Secondly, and more immediately, it defines a point threat to be neutralized or avoided in the transit of CARGRU ONE to the selected operating area. In view of the fluidity of the general situation in the ONRODA theater, it is deemed advisable to avoid the submarine's 100 N Mi weapon range by end-run to the northward. (Mere avoidance of the submarine's detection range is considered insufficient in view of the fact that the location of a Red AGI, which is known to be in the operating theater, has been unknown for an extended period). Accordingly, a second transit route which diverts the track to the northward sufficiently to ensure a CPA of 120 N Mi is defined.

2.5 Use of Data Displays

In the two illustrative examples of decision aiding techniques described in this report the user is provided with a series of visual aids that he may call up as desired to assist him in formulating his ultimate decision. These consist of interactive alphanumeric and graphic displays in which data germane to the problem at hand has been retrieved upon command, summarized and formatted for quick, precise assimilation by the user. Included, as well, is the capability for the user to exercise trial solutions and analyze their outcome.

At the start of the sequence the user is presented an alphanumeric display which lists the categories of data displays he may exercise to aid him in arriving at his solution, and the user is requested to enter through a keyboard the category he wishes to examine. As each category is called up by the user, and they may be called up in any order and at different levels of detail, the user is presented with further prompts or requests to select options from a displayed menu.

A way of summarizing numerical data associated with specific geographical areas is the dot grid in which the density of dots within an area is proportional to the numerical value to be represented. This type of data display expresses the results in a clear, concise visual form that can quickly be interpreted by the user. In order to apply the dot grid display, the geographic area under consideration is divided into equal squares. The number of dots in each square is proportional to the value of the parameter being considered, or represents a figure of merit for the area within the square. For example the dots within a square may be proportional to the tons of bombs that can be delivered per day against ONRODA airfield if the Task Force were stationed within that square.

Since the two decision problems considered are geographical or area oriented, many of the data displays consist of graphical data overlayed on a map display which is presented on the left screen with supplementing alphanumeric data on the right screen.

Although data can be entered through a keyboard, the use of a light pen type of device that would permit the user to trace a tentative route on the map display would permit rapid examination of alternate courses.

Of additional interest to the tactical commander is the facility to solve and display the results of relative motion vector problems. A computerized maneuvering board type of presentation was employed which provides the user with immediate comprehension of the relative motion involved in hypothesized situations and gives a visual description of the associated time, distance and speed parameters.

Although these data displays present computer processed data and calculated results in an easy to assimulate visual form, they do not formulate any judgement decisions. The user controls the amount of computer aiding he wishes, selects the input data, and forms his own decisions. The data displays can however greatly reduce the effort that would normally be required by him for data retrieval, organization, condensation, and assimilation. They also serve as a check list to assure he explores the major facets pertaining to the decision making process.

2.6 Example of Best Operation Area Selection

Presented in this section is a step-by-step example of how the data displays previously discussed would be used by the Task Force Commander and his staff to aid in the selection of the best area to station their Task Force for the purpose of carrying out the desired mission. A series of graphic and alphanumeric displays are presented in the same order they would normally be called up by the user. The displays which would appear on the left screen are shown on the left pages and right screen presentations on right pages. The operational use of each set of displays is explained by the text located under the set of displays.

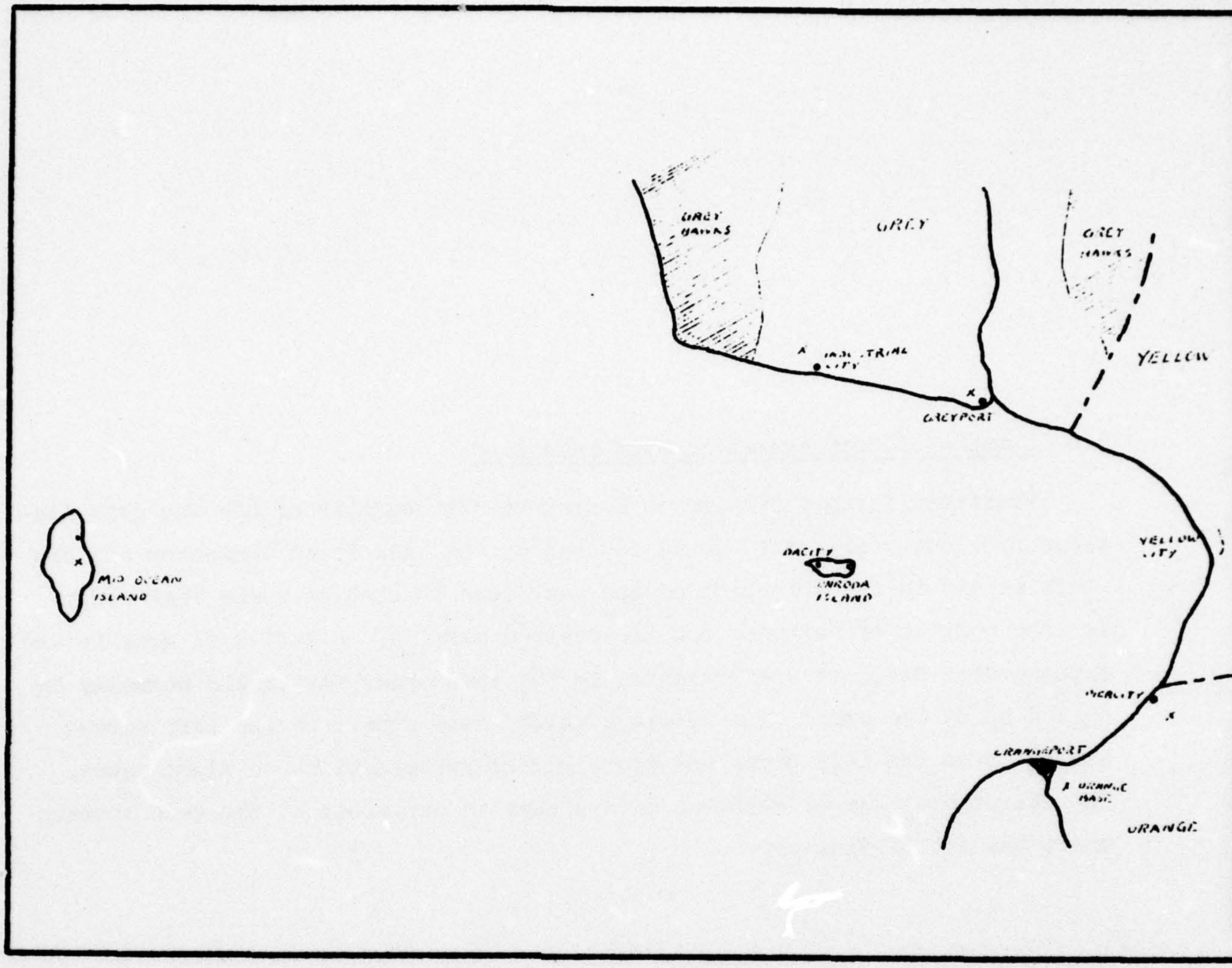


FIGURE 2-3 TARGET AREA MAP

The user, having selected the Best Operations Area Mode, is shown Figure 2-4 - Mission Parameters on the right hand screen, in which he is requested to designate three mission related parameters:

- Primary Mission Objectives - enters mission number (M)
- Target Area - enters zone number (Z)
- Mission Time - enters start and duration (S and D).

After entry of these mission parameters Figure 2-3, Target Area Map, is displayed on the left hand screen for reference purposes. The Target Area Map is a fixed display which shows the areas occupied by Grey, Yellow and Orange

```
PRIMARY MISSION OBJECTIVES
--------------------------
M-1  AIR STRIKE
M-2  AIR SUPERIORITY
M-3  COUNTER AIR
M-4  ANTI-SHIPPING
M-5  ASW DEFENSE
M-6  AAW
M-7  AMPHIB SUPPORT

TARGET AREA
-----------
Z-1  ONRODA
Z-2  RED CITY
Z-3  ALAVA

MISSION TIME
------------
S  START (DAY-HR-MIN)
D  DURATION (DAY-HR-MIN)

ENTER
-----
M
Z
S
D
```

FIGURE 2-4 MISSION PARAMETERS

forces and location of key strategic installations. This map may be called up at any future time by the user for reference. The user would next activate the CONTINUE mode and the following displays would appear.

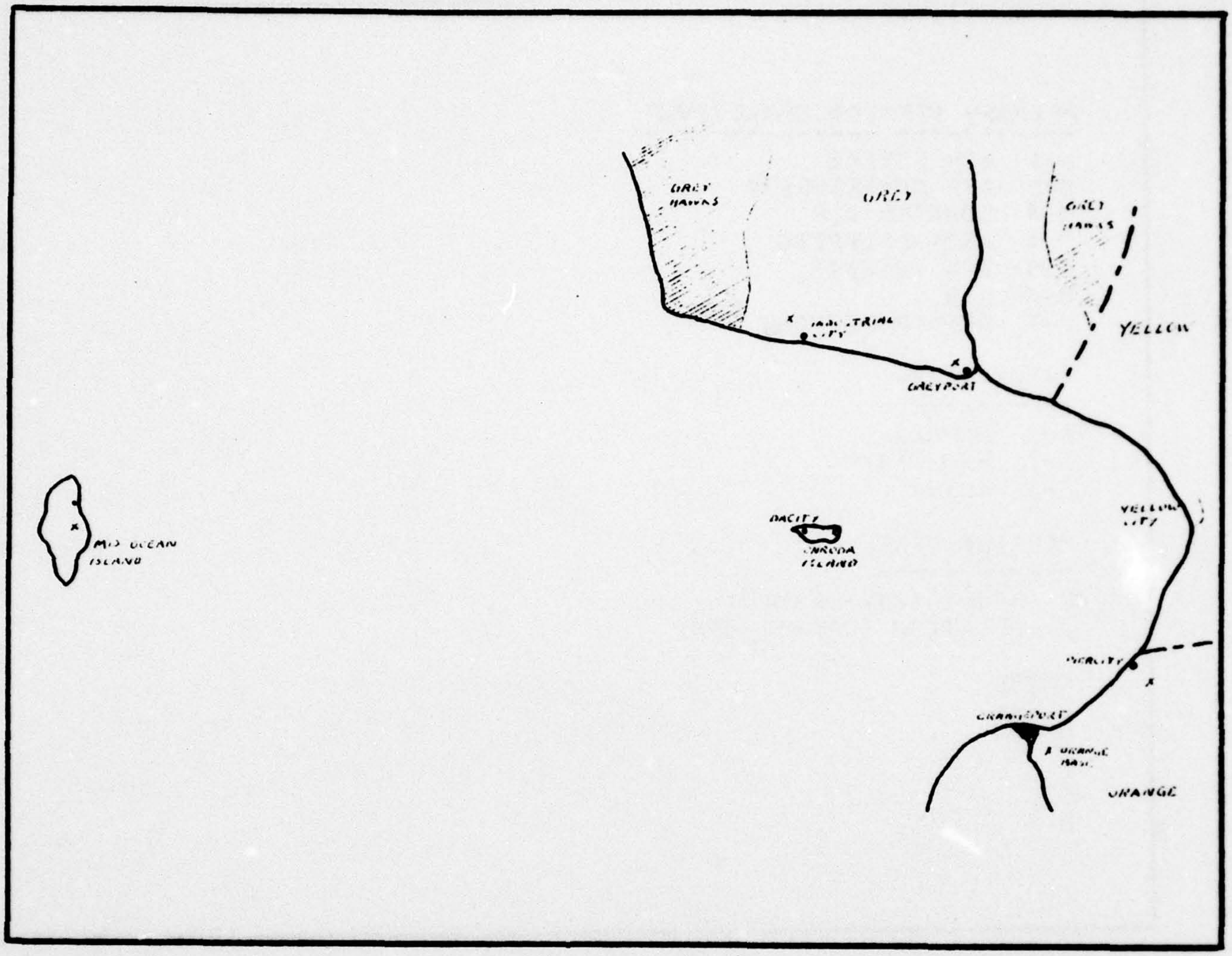


FIGURE 2-5 TARGET AREA MAP

Listed in Figure 2-6 - Ops Areas Factors are 8 factors the user may wish to examine before selecting an operating area from which to conduct the air strikes. All eight factors would normally be selected one at a time and in order by the user. However, when short of time, the user may select only those factors he wishes to examine. His selections should include Factor 1 - WEAPON SYSTEM EFFECTIVENESS, as this is an interactive display in which he sets the target and weapon mix criteria. Once the user responds to the questions asked in Factor 1, he may proceed directly to Factor 5 which summarizes the results of Factors 1 through 4 and shows a dot grid presentation indicating those geographical operating areas in which the vulnerability/effectiveness ratio is minimized.

```
OPS AREA FACTORS
----------------

F1   WEAPON SYSTEMS EFFECTIVENESS
F2   VULNERABILITY TO AIR THREAT
F3   VULNERABILITY TO SURFACE THREAT
F4   VULNERABILITY TO SUB-SURFACE THREAT
F5   VULNERABILITY/EFFECTIVENESS SUMMARY
F6   LOGISTIC SUPPORT
F7   OPERATING CONSTRAINTS
F8   AIRCRAFT ROUTE PLANNING

ENTER
-----
F
```

FIGURE 2-6 OPS AREA FACTORS

Factors 6, 7, and 8 are not interactive displays, and selecting these factors results in pertinent information being displayed in alphanumeric tables and graphic formats for the user's examination. The normal procedure of calling up all the factors in order is demonstrated in this text. Figure 2-5, which is the same as Figure 2-3, remains on the left screen until the user selects Factor 1 - WEAPON SYSTEMS EFFECTIVENESS at which time the displays shown on the next two pages appear.

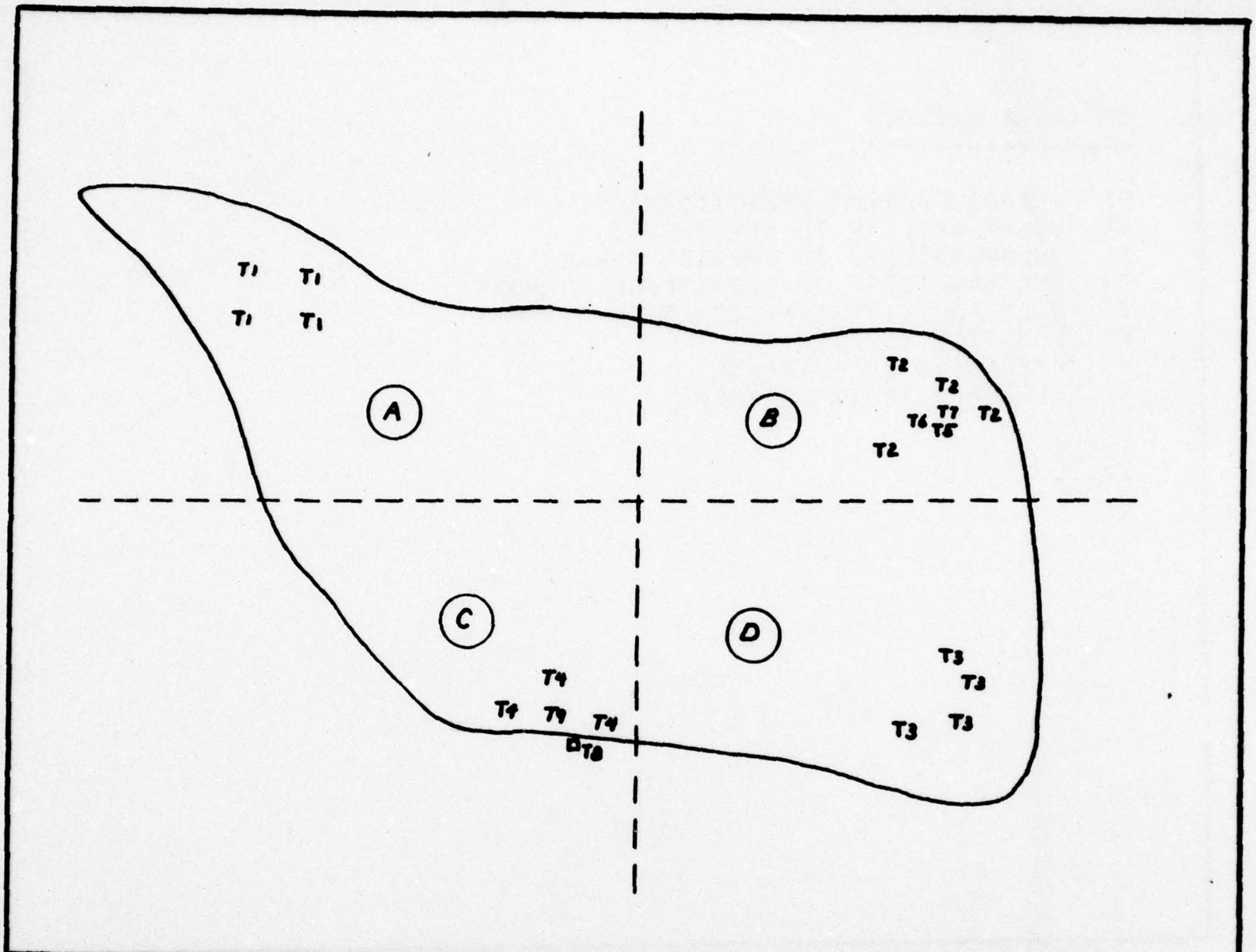


FIGURE 2-7 TARGETS - ONRODA ISLAND

The user, having selected WEAPON SYSTEMS EFFECTIVENESS as the Ops Area Factor, would be presented with an interactive display, Figure 2-8 - Air Strike Targets and Weapons, on the right and Figure 2-7 - Targets - ONRODA Island on the left. ONRODA Island has been divided into four zones A, B, C and D as indicated on Figure 2-7. The precise coordinates of the targets are known, of course, however, for the purpose of the forthcoming display presentations it suffices to group the target locations into four quadrants in order to simplify the computations that would be required if the system was actually

```
TARGETS ON ONRODA                ZONE LOCATION
-----------------                -------------

T1  SAM BATTERIES                      A
T2  SAM BATTERIES                      B
T3  SAM BATTERIES                      C
T4  SAM BATTERIES                      D
T5  FIGHTER AIRCRAFT AT AIRFIELD       B
T6  AIRFIELD RUNWAYS                   B
T7  AIRFIELD FUEL DEPOT                B
T8  COMBAT SHIPS AT DOCK               C
T9  DOCK FUEL DEPOT                    C

AIRCRAFT AVAILABLE  WEAPONS AVAILABLE
------------------  -----------------

W1  A-6E  (24)      11-HARM, 12-SHRIKE, 13-LGB MK 83
W2  A-7E  (48)      21-LGB MK 84, 22-LGB ROCKEYE

TYPE OF PRESENTATION
--------------------

P1  KILOTONS/DAY
P2  PROBABILITY OF NEUTRALIZATION

ENTER
-----
T
W
P
```

FIGURE 2-8 AIR STRIKE TARGETS AND WEAPONS

implemented. The user selects a target by entering the "T" number. He selects the aircraft he wishes to deploy and the weapon mix by entering the "W" number and the appropriate two digit number. The computer now has enough information to determine either (P1) the kilotons per day that could be dropped on the selected target with the selected aircraft and weapon mix as a function of the range from target, or (P2) probability of neutralizing the target within a time span of 24 hours with the selected aircraft and weapon mix as a function of the range from the target. The user selects either (P1) or (P2) or both.

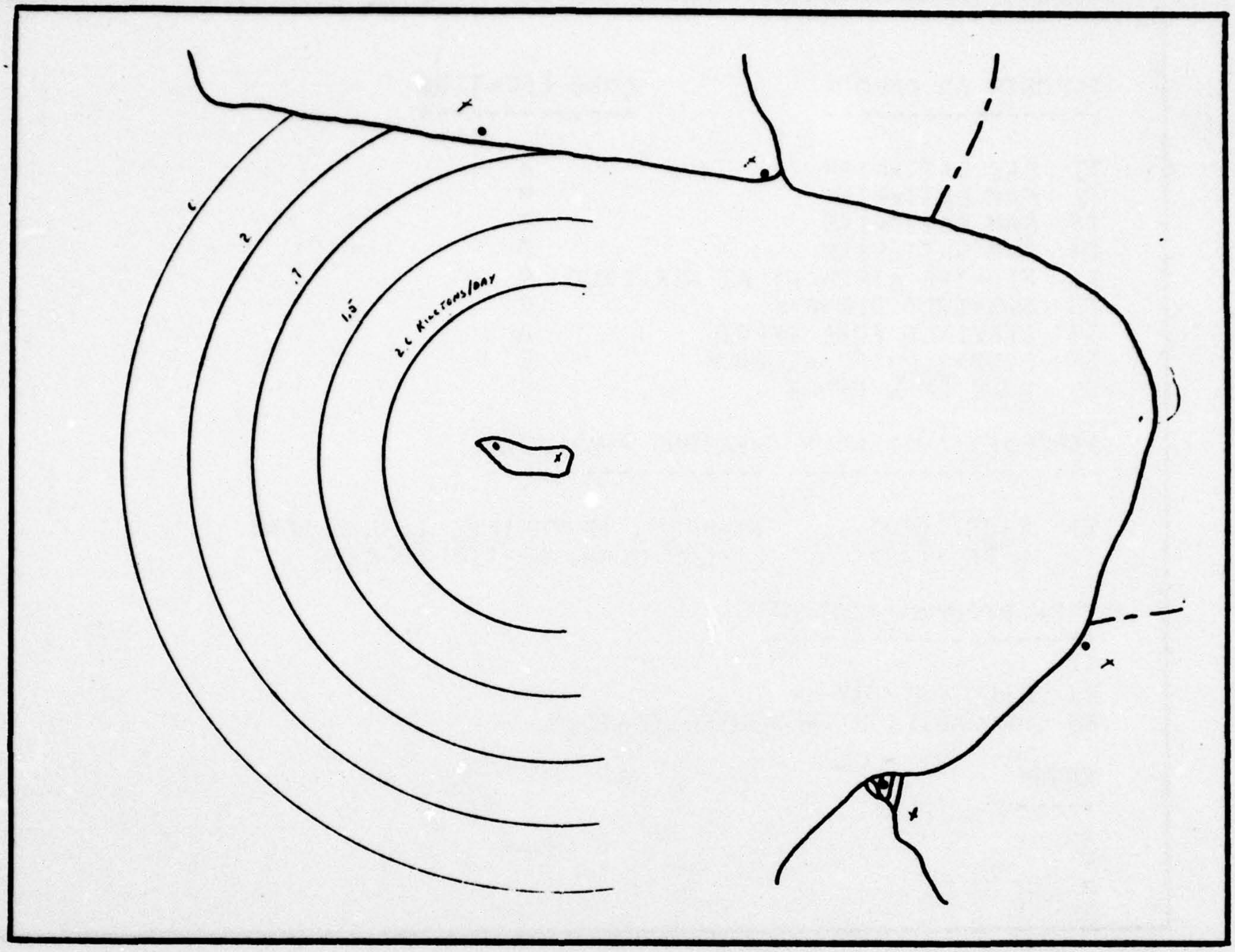


FIGURE 2-9 WEAPON DELIVERY CAPACITY KILOTONS/DAY

If the user selects kilotons/day then Figure 2-9 would appear on the left screen and Figure 2-8 shown on the previous page would remain on the right screen. Figure 2-9 is computed based on one-half of the selected aircraft flying each sortie. The weight of the fuel required for the aircraft to reach the target, perform the air strike and return plus the weight of required reserve fuel is subtracted from the aircraft's total payload capacity for each range increment when determining weapon delivery capacity. If the user selects PROBABILITY OF NEUTRALIZATION, then Figure 2-10 would appear on the left screen and Figure 2-8 remain on the right screen. Figure 2-8 remains interactive enabling the user to try other selections and view the corresponding

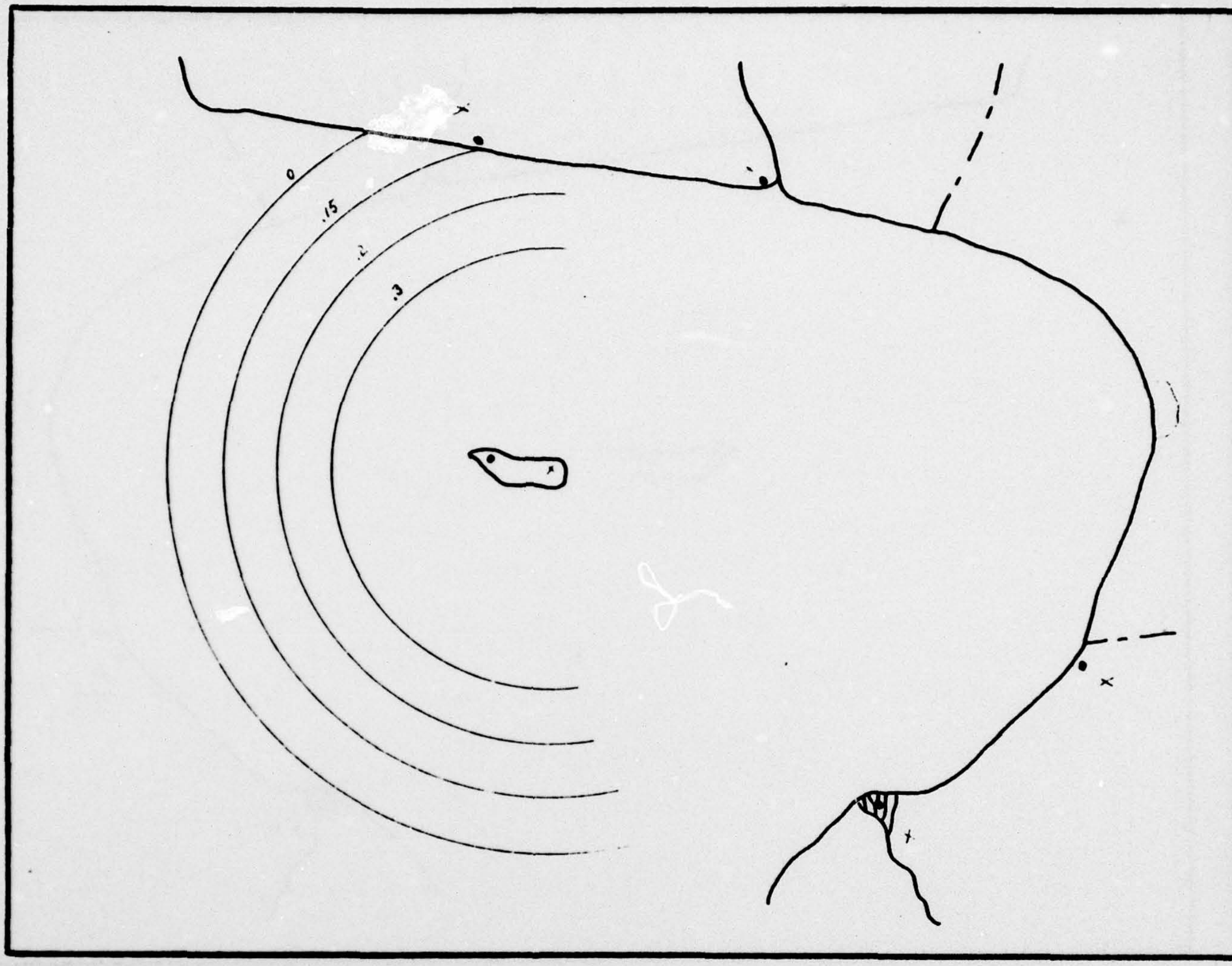


FIGURE 2-10 PROBABILITY OF NEUTRALIZING TARGET

results on the left screen. If the user elects to view both the kilotons and probability presentations simultaneously, Figure 2-9 is shown on the left screen and Figure 2-10 on the right. PROBABILITY OF NEUTRALIZING THE TARGET is normally a time dependent function (i.e., number of sorties flown). In this presentation the probability of neutralization is computed by allotting the payload that can be delivered within 24 hours (which is a function of the range from Ops Area to target) equally among the selected weapons. At this time, probability of neutralization is computed without regard to enemy defenses. PROBABILITY OF SURVIVAL (VULVERABILITY) is introduced next. Figures 2-9 and 2-10 allow the user to examine where he should station his Task Force to achieve relative degrees of effectiveness while operating unopposed. He may bypass these displays and elect to go directly to the combined Vulnerability-Effectiveness displays (Figures 2-21 and 2-22).

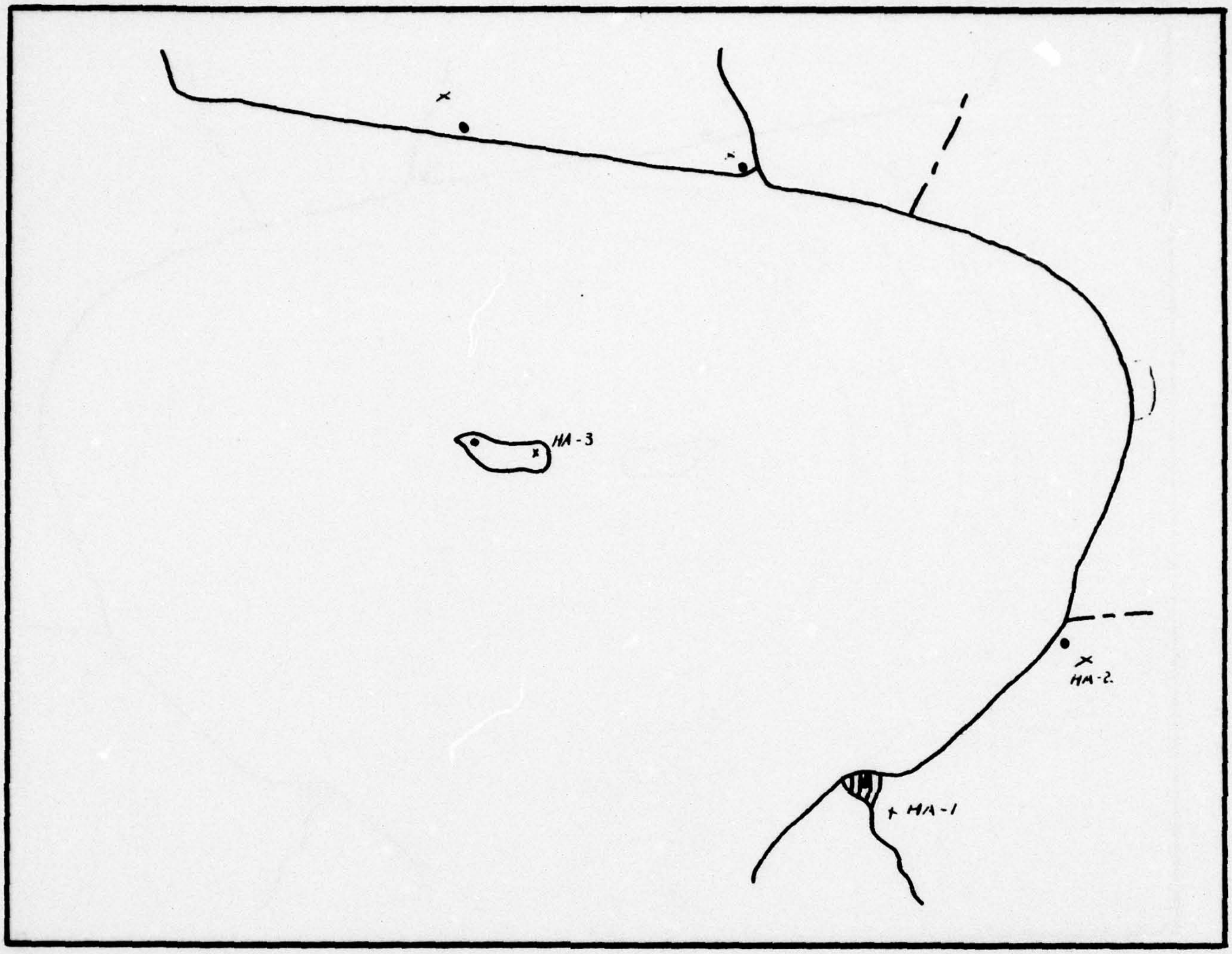


FIGURE 2-11 AOB MAP DISPLAY

Having examined own force effectiveness as a function of Ops Area location the user can now explore own force vulnerability as a function of Ops Area location.

Vulnerability to air, surface and sub-surface threat can be examined separately. The user would again call up Figure 2-6 - Ops Area Factors and select Option 2 - VULNERABILITY TO AIR. Figure 2-12 - Air Order of Battle (AOB) would appear on the right screen and Figure 2-11 - AOB Map Display on the left. These displays allow the user to analyze the AOB situation. Other data such as enemy aircraft combat radius for various weapon loads, although not shown in this test, can also be called up by the user for review. The ONRODA scenario dictates that no military aircraft are currently based on ONRODA Island.

```
AOB DATA
--------

AIRFIELD              AIRCRAFT            NUMBER
--------              --------            ------

HA-1  ORANGEPORT      TU-16A   BADGER     10
                      IL-28   BEAGLE      36
                      SU-7  FITTER        40
                      MIG-19   FARMER     28
                      MIG-21   FISHBED    90

HA-2  PIER CITY       TU-16A   BADGER     14
                      IL-28   BEAGLE      18
                      SU-7  FITTER        32
                      MIG-19   FARMER     44
                      MIG-21   FISHBED    54

HA-3  ONRODA I        NONE - HOWEVER FIGHTERS CAN BE STAGED

TYPE OF PRESENTATION
--------------------

P1 - KILOTONS/DAY
P2 - PROBABILITY OF NEUTRALIZATION

ENTER
-----
P-
```

FIGURE 2-12 ENEMY AIR ORDER OF BATTLE

However, fighters could be staged there to provide escort for the Badger and Beagle bombers. The maximum ranges used in the following delivery capability displays are based on the maximum escort range of MIG-21 fighters staged at ONRODA Island. The user can now select the type of presentation desired:

- P1 - Kilotons of weapons the enemy aircraft could deliver on the Task Force per day as a function of task force location, or
- P2 - Probability of neutralization, or both

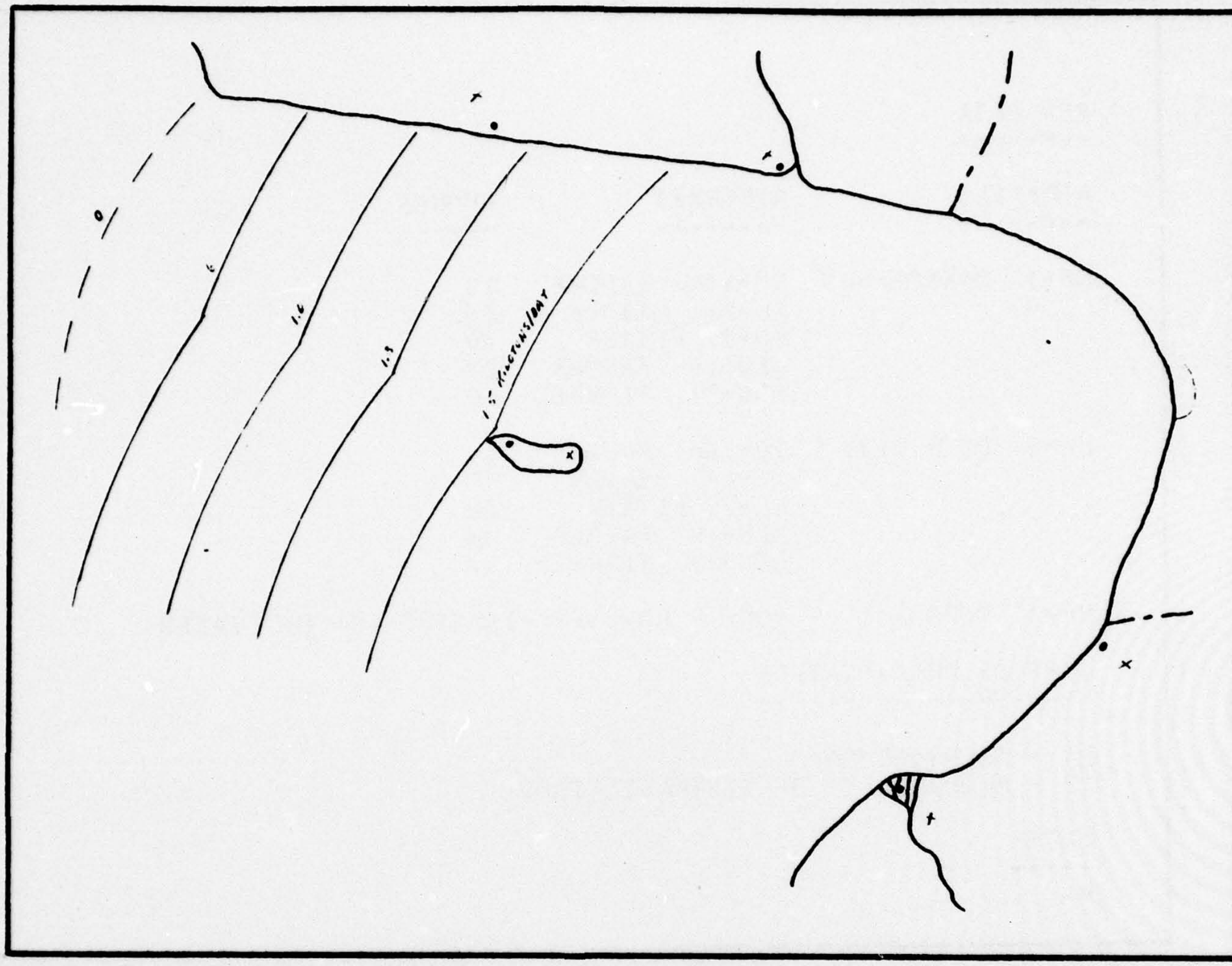


FIGURE 2-13 ORANGE AIR THREAT - KILOTONS/DAY

If the user selects kilotons/day, then Figure 2-13 appears on the left screen and Figure 2-12 shown on the previous page would remain on the right screen. Figure 2-13 is based on one-half of the aircraft stationed at each airfield (HA-1 and HA-2) making each sortie. The dotted curve represents the maximum escort range of MIG-21s that were refueled at ONRODA Island, and represents the cut-off point beyond which bombers would not penetrate without fighter escort. As previously, delivery capacity is payload minus fuel for a specific range. If the user selected PROBABILITY OF ORANGE

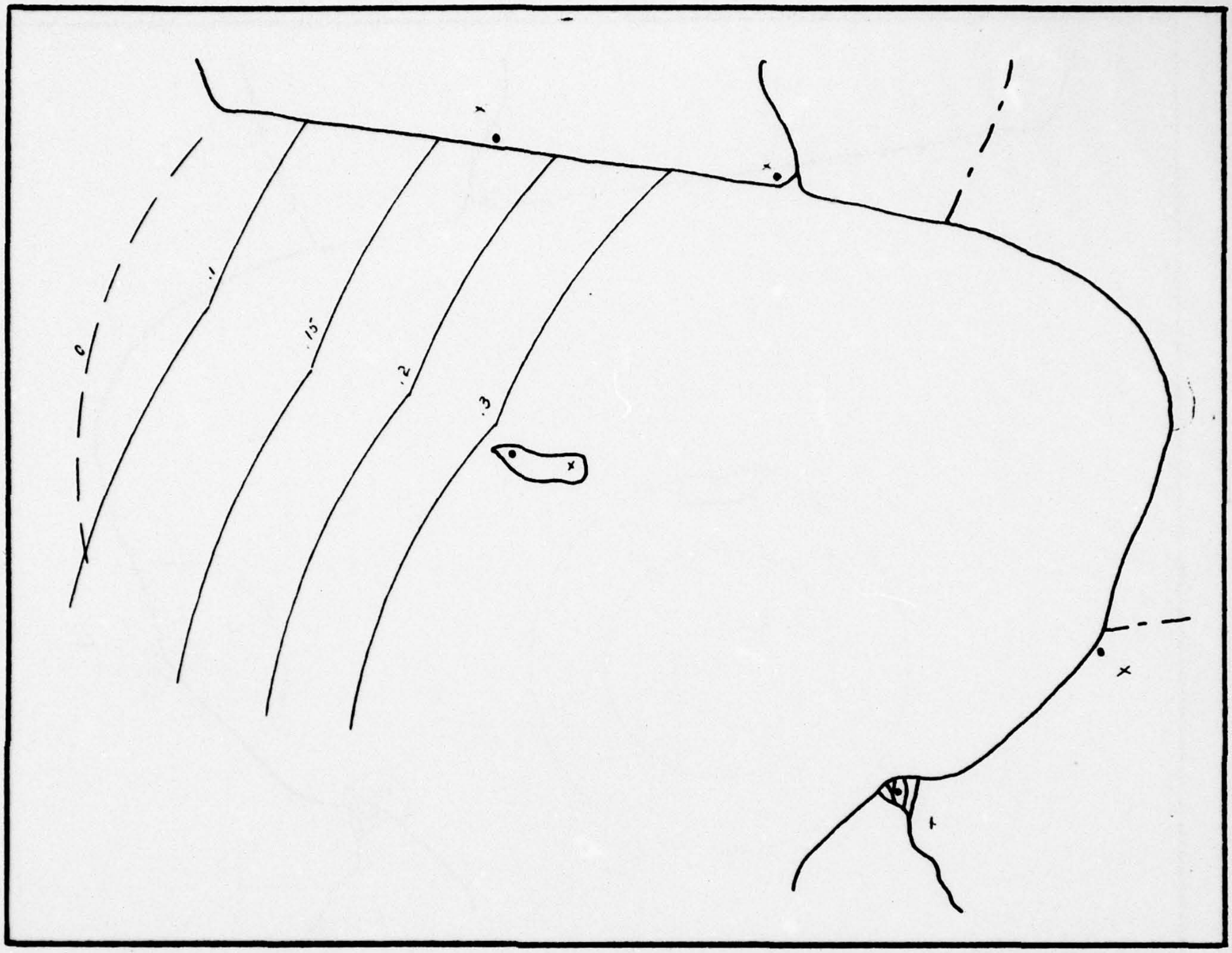


FIGURE 2-14 PROB. OF ORANGE NEUTRALIZING TASK FORCE - AIR

NEUTRALIZING OWN TASK FORCE, then Figure 2-14 would appear on the left screen and Figure 2-12 remain on the right. If both Figures 2-13 and 2-14 are selected simultaneously they would appear as shown above. Hostile effectiveness in both figures is computed without regard to own Task Force defense capability.

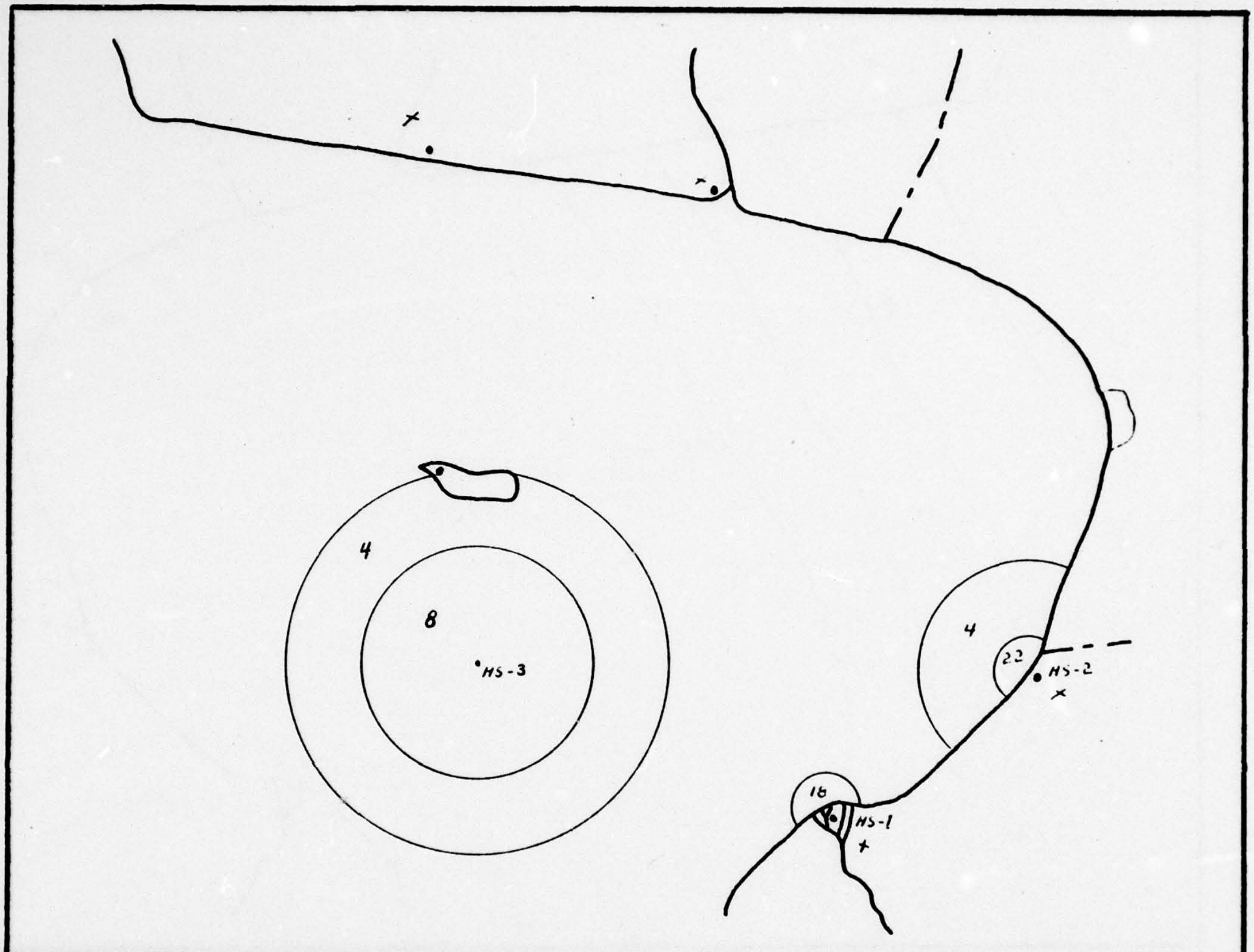


FIGURE 2-15 ENEMY MISSILE DELIVERY CAPABILITY

The user would now proceed to examine the Task Force vulnerability to surface threat. This would be done by calling up Figure 2-6 - Ops Area Factors and selecting Factor 3 - VULNERABILITY TO SURFACE THREAT. Figure 2-16 - Surface Threats would then be displayed on the Right Screen. This display enables the user to examine the location and quantity of surface threats. He then selects whether he wishes to display "current status" or "furthest on". Current status, which is called by entering T=0, displays the missile coverage as shown in Figure 2-15 - Enemy Missile Delivery Capability.

```
SHIPS LOCATION         TYPE           NO
--------------         ----           --

HS-1   ORANGEPORT      OSA            3
                       KOMAR          3
                       P-6            6

HS-2   PIER CITY       DD             4
                       OSA            3
                       KOMAR          3
                       P-6            6
                       AMPHIB         5
                       T-43           2
                       WHISKEY        2

HS-3   SOUTH OF ONRODA KRESTA
                       DD KRIVAK
                       DLG KASHIN
                       DD SKORY

DISPLAY CURRENT STATUS (SPECIFY TIME T=0)

DISPLAY FURTHEST ON (SPECIFY TIME IN HRS)

P1 = MISSILE COVERAGE, P2 = PROB OF NEUTRALIZATION

ENTER
-----
T-
P-
```

FIGURE 2-16 SURFACE THREATS

The numeric character within each range circle on Figure 2-15 represents the number of missiles that can reach any spot within that circle if all enemy missile carrying ships launch their full deckload. The position of the enemy task force is designated by code numbers (i.e., HS-3) displayed by the center of the circle.

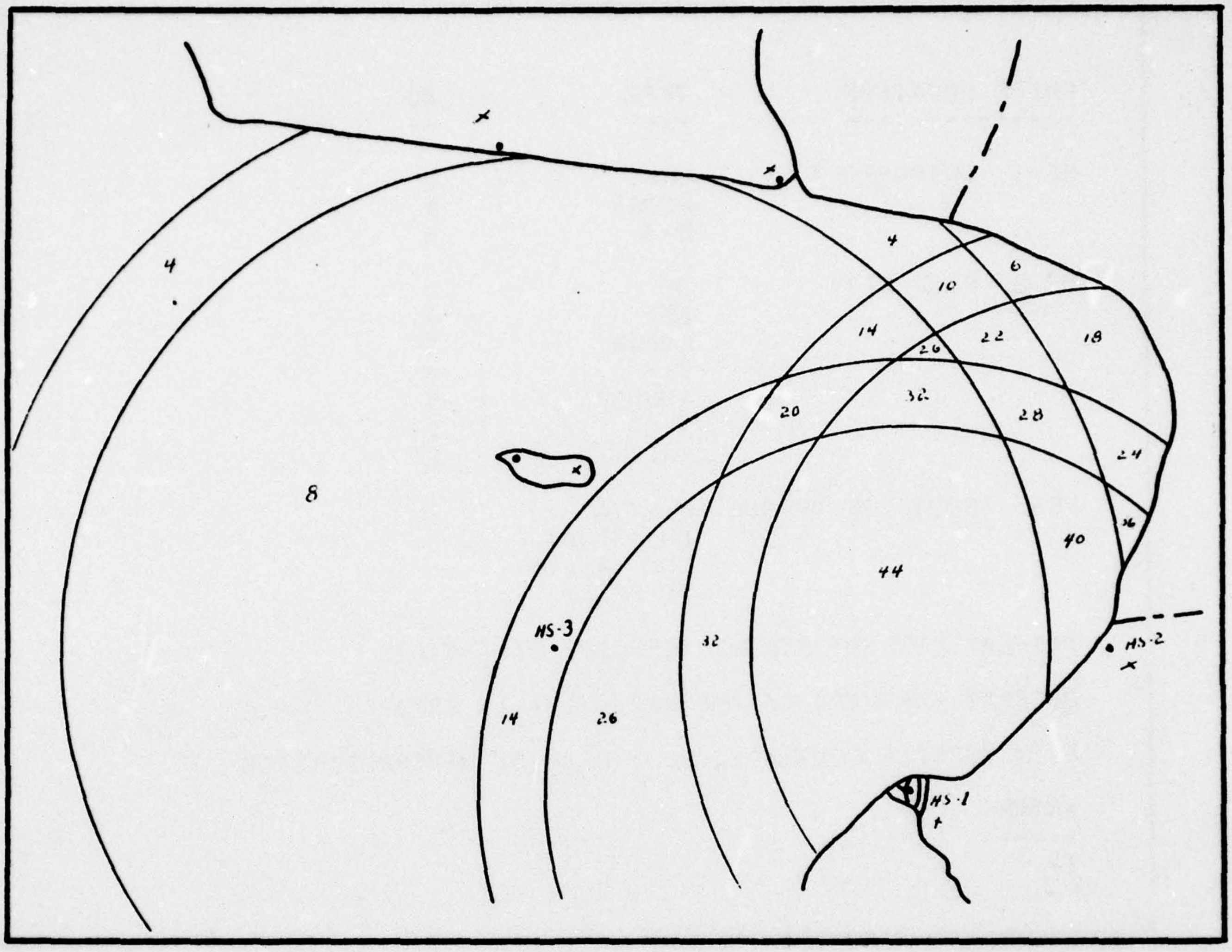


FIGURE 2-17 ENEMY MISSILE DELIVERY CAPABILITY - 12 HRS

If the user wishes to examine what the Task Force vulnerability to surface threats would be at some future time, he may specify the time increment from present to desired future time in hours (Display "Furthest On" entry in Figure 2-16). The distance each surface threat could travel in the specified time increment is then computed and added to its missile range. Using 12 hours as an example, the missile coverage would then be displayed as shown in Figure 2-17 - Enemy Missile Delivery Capability - 12 Hrs. This represents a worst case condition, since it shows the maximum number of missiles that could be brought to bear upon a Task

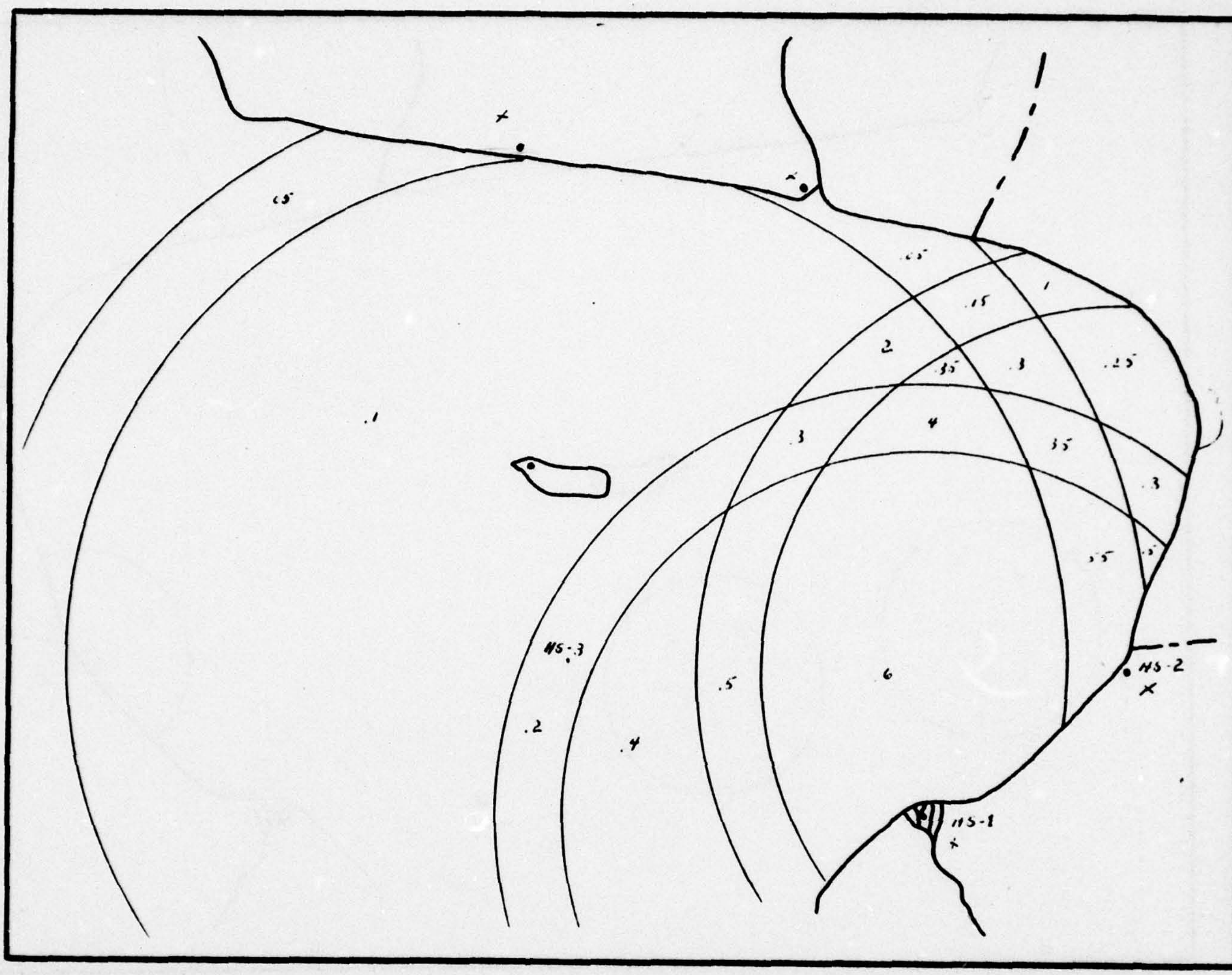


FIGURE 2-18 PROB. OF ORANGE NEUTRALIZING TASK FORCE - SURFACE

Force in each area if all missile carrying ships steamed toward that area for 12 hours and launched their complete deck load of missiles at the Task Force. If desired, the user may display enemy surface threat capability as a function of probability as shown in Figure 2-18 - Probability Of Orange Neutralizing Task Force-Surface, by selecting the P2 Option shown in Figure 2-16. Probability of neutralization may be displayed for either "Current Status" or "Furthest On".

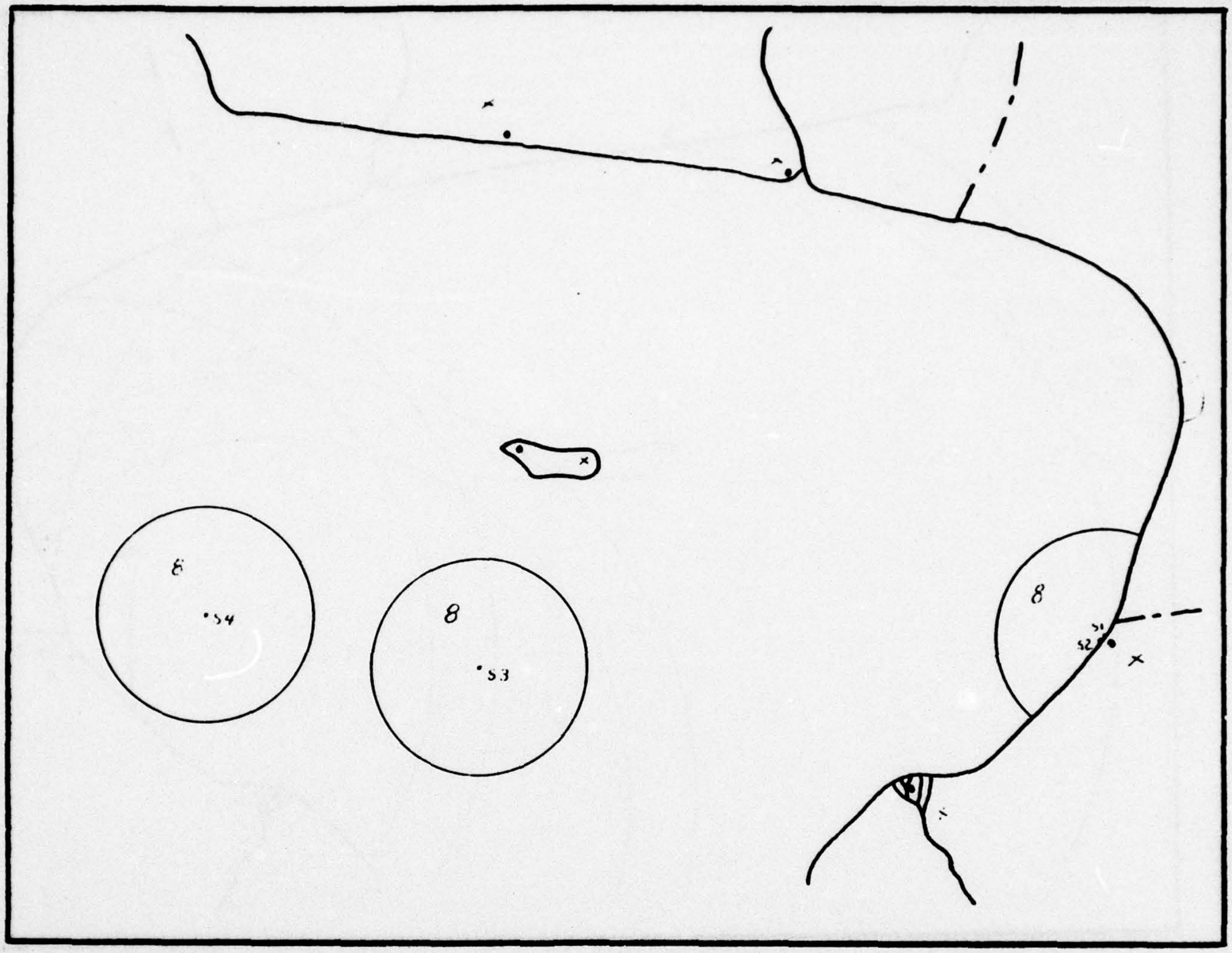


FIGURE 2-19 ENEMY SUB LAUNCHED MISSILE COVERAGE

The user would now proceed to examine Task Force vulnerability to sub-surface threats by calling up Figure 2-6 - Ops Area Factors and selecting Factor 4 - VULNERABILITY TO SUB-SURFACE THREATS. Figure 2-20 - Sub-Surface Threats would then be displayed on the right screen. The user would select either "CURRENT STATUS" or "FURTHEST ON" and specify time as he did when analyzing surface threats. The user would also select type of presentation. If he selected P1 - MISSILE COVERAGE and CURRENT STATUS, Figure 2-19 - Enemy Sub Launched Missile Coverage would appear on the left screen. Unless the submarine is in port its precise location is generally not known. The user viewing Figures 2-19 and 2-20 can see the submarine's approximate position at the time of its last contact. If he requests FURTHEST ON (say after

```
SUBMARINE CLASS   LOCATION             LAST SIGHTING
---------------   --------             -------------

WHISKEY           S1 - PIER CITY       281300Z
WHISKEY           S2 - PIER CITY       281300Z
ECHO II           S3 - S OF ONRODA     290700Z
ECHO II           S4 - SW OF ONRODA    301500Z

DISPLAY CURRENT STATUS (SPECIFY TIME = 0)

DISPLAY FURTHEST ON (SPECIFY TIME IN HRS)

TYPE OF PRESENTATION
--------------------

P1 = MISSILE COVERAGE, P2 = PROB OF NEUTRALIZATION

ENTER
-----
T-
P-
```

FIGURE 2-20 SUB-SURFACE THREATS

12 hours) the distance the submarine can travel at submerged running speed for that time is added to the missile range and a display similar to Figure 2-17 for surface threats would result. As in the surface threat case, the probability of the Orange submarines neutralizing the Blue Task Force may be displayed for either "CURRENT STATUS" or "FURTHEST ON". The effects of torpedoes were not included as the torpedo range circles that would have to be be added would be too small to be noticed on the display for the "CURRENT STATUS" case. However, their effects could be included in the "FURTHEST ON" case by letting their coverage area be equal to the submarines cruising range during the specified time interval.

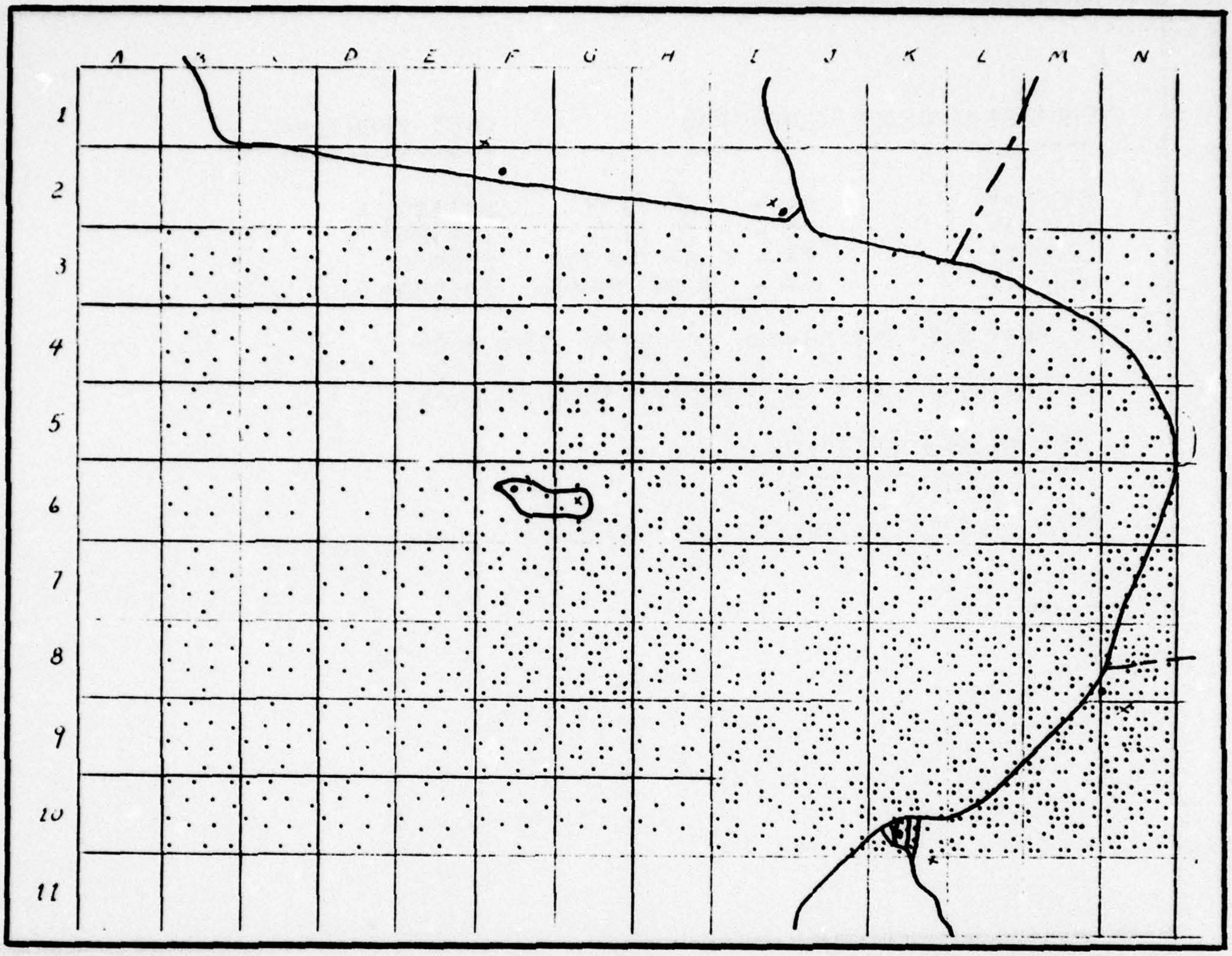


FIGURE 2-21 DOT GRID - VULNERABILITY-EFFECTIVENESS SUMMARY

The user has now examined own force effectiveness against a selected target and own force vulnerability to air, surface and sub-surface threats, all as a function of own force position for given orders of battle. He is now in a position to try and combine all this data somehow to determine the best operating area for his task force based on generated effectiveness and vulnerability information. This is where the dot grid presentation of computer generated results can serve as an effective aid for the user. The user would once again call up Figure 2-6 - Ops Area Factors and select Factor 5 - VULNERABILITY/EFFECTIVENESS SUMMARY. Figure 2-21 - Dot Grid - Vulnerability-Effectiveness Summary, without the dots would appear on the left

AREA	VULNERABILITY AIR	SURF	SUB	OWN EFFECT	FOM
D-5	.15	.10	.12	.2	10
E-5	.25	.10	.15	.3	9
D-6	.15	.15	.21	.2	7
E-4	.18	.10	.15	.2	7
C-6	.28	.10	.17	.3	5
C-7	.12	.10	.30	.15	5

ENTER BOUNDARIES/LANES

LEFT-
RIGHT-
TOP-
BOTTOM-

FIGURE 2-22 VULNERABILITY - EFFECTIVENESS SUMMARY

screen and Figure 2-22 - Vulnerability - Effectiveness Summary without numbers would appear on the right screen. The user would specify the boundaries of the dot grid presentation by identifying the rows and columns (i.e., B-N, 3-10), causing the dots in Figure 2-21 and numbers in Figure 2-22 to be filled in. The less dots within a grid square on Figure 2-21, the better it is as an operating area for the Task Force considering vulnerability and effectiveness. The best areas, in order, are identified with corresponding data in Figure 2-22. The numbers in Figure 2-22 represent the probabilities previous discussed, except for FOM (Figure of Merit) which is a normalized relative rating.

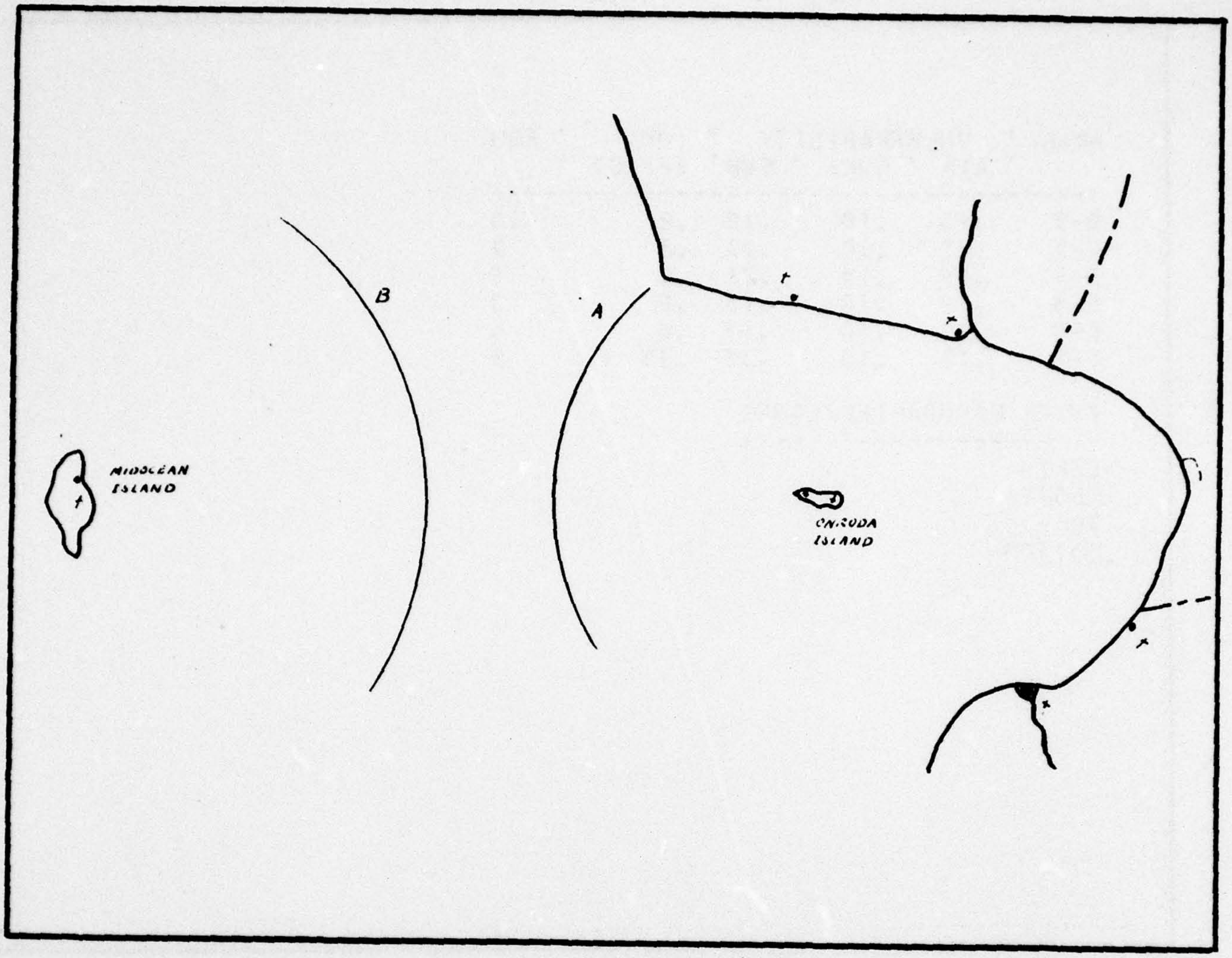


FIGURE 2-23 URG RENDEZVOUS AREAS

Once the user has analyzed the VULNERABILITY - EFFECTIVENESS SUMMARY he may wish to examine in which areas he can be best supported by Underway Replenishment Group (URG). This is done by calling up Figure 2-6 and selecting Factor 6 - LOGISTIC SUPPORT. Figure 2-24 - Radii Of Action and Figure 2-23 URG Rendezvous Areas are displayed as shown. Figure 2-23 shows the maximum distance the MIG-21 fighters could escort the Orange bombers (i.e., Badgers). This envelope is shown as boundary line A and it may be assumed that areas to the left of line A would be safe from attack by orange bombers. Line B in Figure 2-23 shows the maximum escort range of blue F-4 fighters based at Mid Ocean Island (MOI). URG ships operating to the right of boundary line B would have no MOI based fighter protection.

BOUNDARY LINE	MEANING
A	MIG-21 ESCORT RADIUS OF ACTION
B	F-4 ESCORT RADIUS OF ACTION

FIGURE 2-24 RADII OF ACTION

Figure 2-24 lists the meaning of each boundary line. Other boundary lines such as the radius of action of patrol boats based at specific ports can be included on the displays. Time related information can also be presented. For example, if the Task Force wished to vacate its operating area for no more than 12 hours for replenishment purposes, range circles could be drawn about the Task Force which represent the maximum distance it could travel, take on fuel and supplies, and return in time. The distance Orange surface forces could travel in the same 12 hours could also be shown.

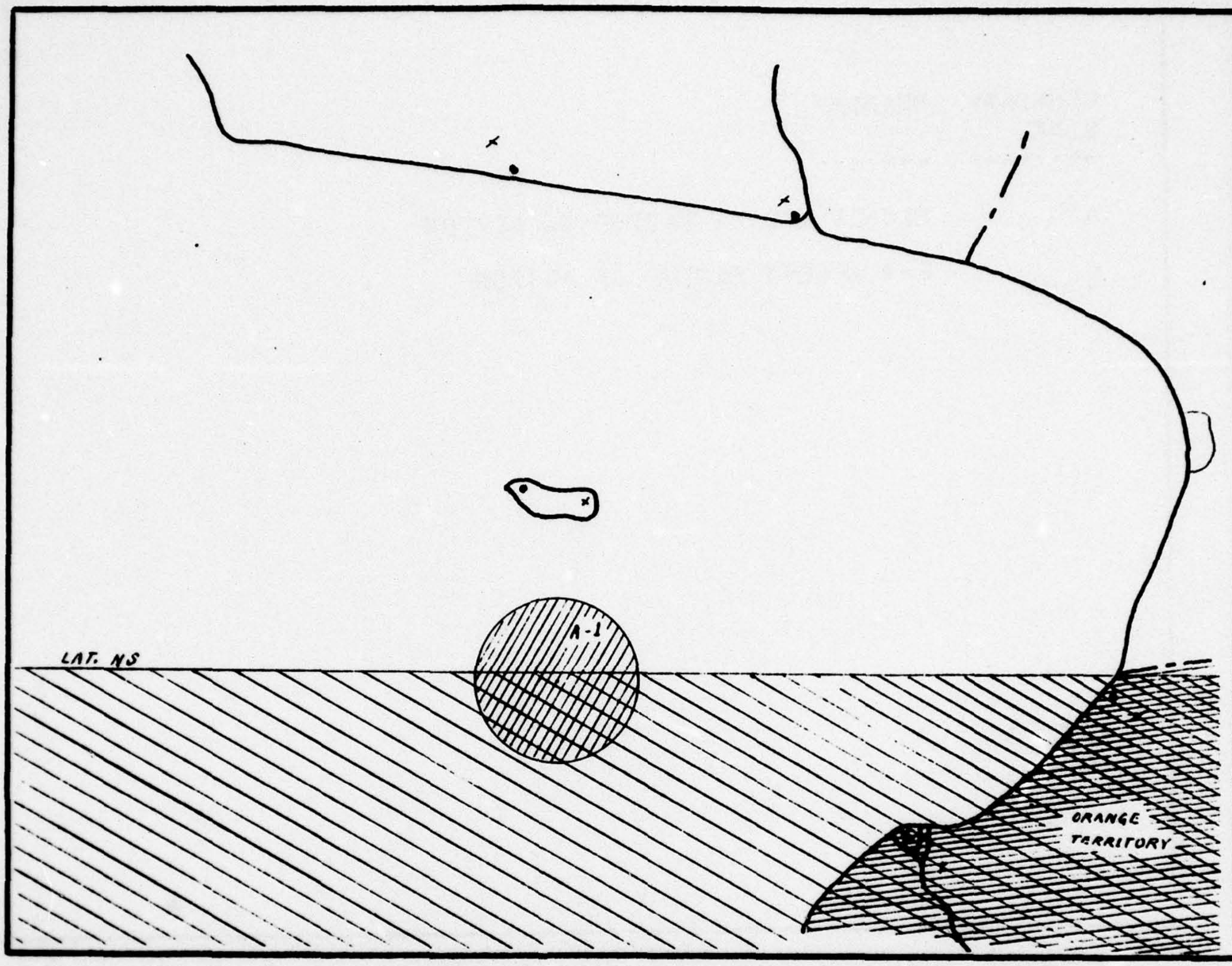


FIGURE 2-25 BOUNDARY CONSTRAINTS

The user may wish to examine operating constraints. This is done by calling up Figure 2-6 and selecting Factor 7 - OPERATING CONSTRAINTS. The information is displayed by Figure 2-25 - Boundary Constraints on the left screen and Figure 2-26 - Operating Constraints on the right screen. Figure 2-25 is a map display with prohibited areas and areas of special interested overlayed. Figure 2-26 defines the significance of the areas and the operating rules regarding them. Figure 2-26 also can present rules of engagement, defense measures, sanctuary areas, general guidance and information pertinent to selecting an operating area. The information

OPERATING CONSTRAINTS	
SANCTUARY	- ORANGE FORCES CANNOT BE ATTACKED IN ORANGE OR IN ORANGE PORTS.
AREAS	- BLUE FORCES RESTRICTED TO AREAS NORTH OF LAT. NS.
	- REMAIN WELL OUT OF RED TRAINING AREA (A1).
NUCLEAR WEAPONS	- NONE WILL BE USED UNLESS DIRECTED BY HIGHER AUTHORITY.
DEFENSE	- TAKE MEASURES TO PROTECT FORCE FROM ORANGE OR RED RETALIATION.
GENERAL GUIDANCE	- AVOID INITIATING HOSTILITIES.
	- RULES OF ENGAGEMENT PER COMBLUEFLT STANDING OPORD.

FIGURE 2-26 OPERATING CONSTRAINTS

contained in the map display (Figure 2-25) could also be shown using a dot grid presentation similar to Figure 2-21. Circular areas however, would have to be approximated by the straight line boundaries of the grid squares. Variations in the density of the dots could define different areas as they overlapped. The information shown on Figure 2-25 could be combined with the information shown on Figure 2-21 in a dot grid presentation. If this were done, it is suggested all prohibited areas be blacked in with the maximum dot density pattern.

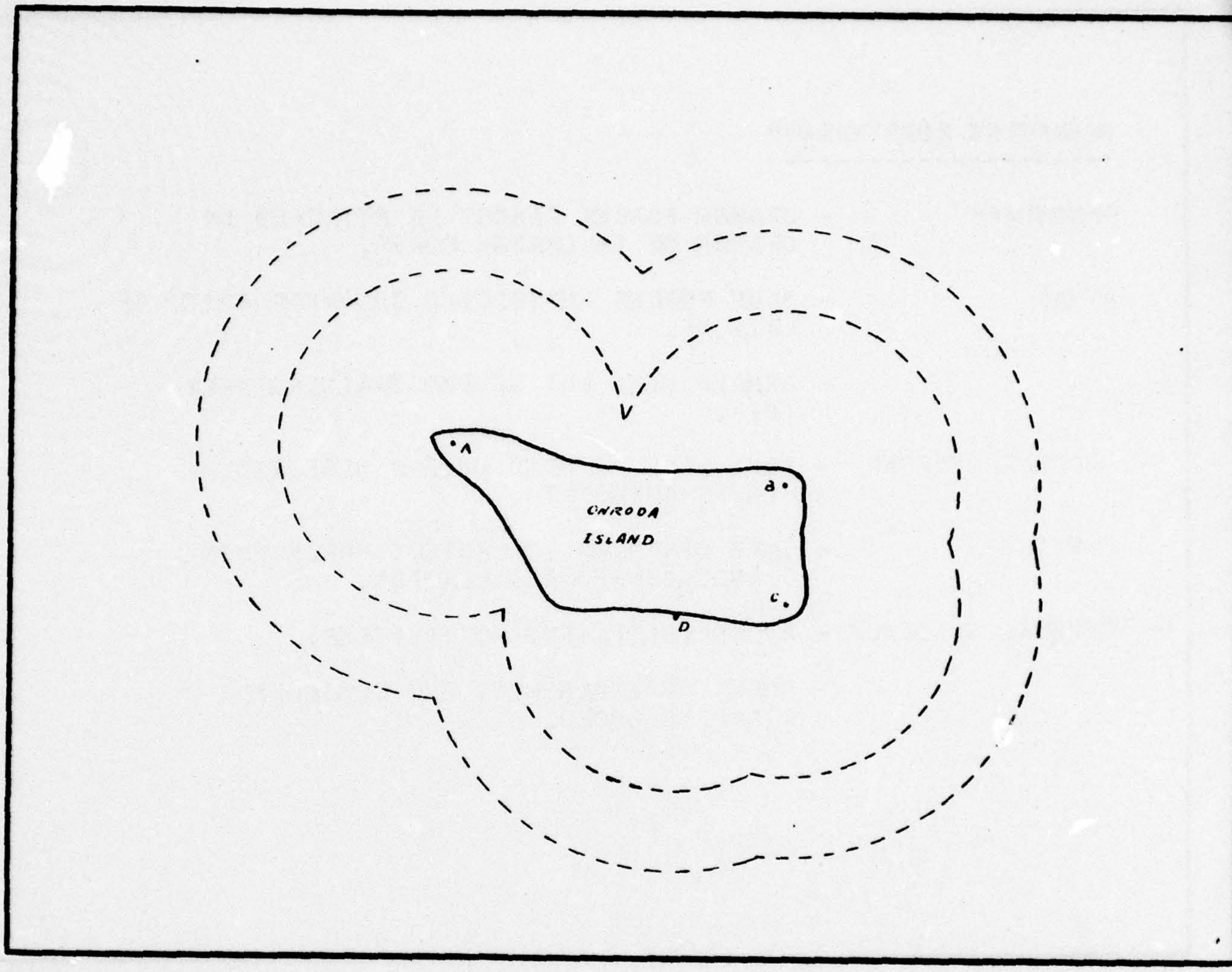


FIGURE 2-27 EARLY WARNING RADAR COVERAGE

The user would now proceed to examine which Ops areas would provide access to favorable air strike penetration routes. This is done by calling up Figure 2-6 again and selecting Factor 8 - AIRCRAFT ROUTE PLANNING. Figure 2-27 and 2-28 would then appear on the left and right screens respectively. The outer dotted boundary line on Figure 2-27 shows the combined radar line of sight (LOS) detection ranges for all Early Warning (EW) radars located on ONRODA Island that would apply to aircraft trying to penetrate at an altitude of 1000 feet above sea level. The inner dotted boundary shows the same information for a

EARLY WARNING RADARS - ONRODA I.

LOCATION	TYPE	COVERAGE - NMI 500 FT PEN.	COVERAGE - NMI 1000 FT PEN.
A	FAN SONG	52	64
B	FAN SONG	44	56
C	FAN SONG	48	60
D	SHIP - MOSCA	37	49

FIGURE 2-28 EW RADAR DATA

500 foot penetration altitude. Figure 2-28 tabulates the radar data used in generating the curves in Figure 2-27. The radar horizon was calculated by considering the elevation of the radar site, the radar antenna structure height and the aircraft penetration altitude. The radar horizons are shown in Figure 2-28 for both the 500 and 1000 ft. aircraft penetration altitudes. It may be noted the radar at location D is aboard a dockside ship. These two displays complete the presentations that may be called up by the user. He may go back and display any previous ones or change any data.

The user, having exercised the available computer aided display capabilities by examining the eight Ops Area Factors, is now in a position to make a decision. Some of the data displays he has examined point him toward one or more specific areas as being the best choices for the specific factors considered. However an attempt is not made to combine, through the computerized mechanization, the results from all eight factors considered. The relative importance of each factor (e.g., weapon system effectiveness, vulnerability, logistic support) in formulating the final decision must be left to the user.

2.7 Example of Transit Route Selection

Presented in this section is a step-by-step example of how the data display would be used by the Task Force Commander and his staff to aid in the selection of the Best Transit Route. The format is the same as was used in the preceding example of Best Operation Area Selection.

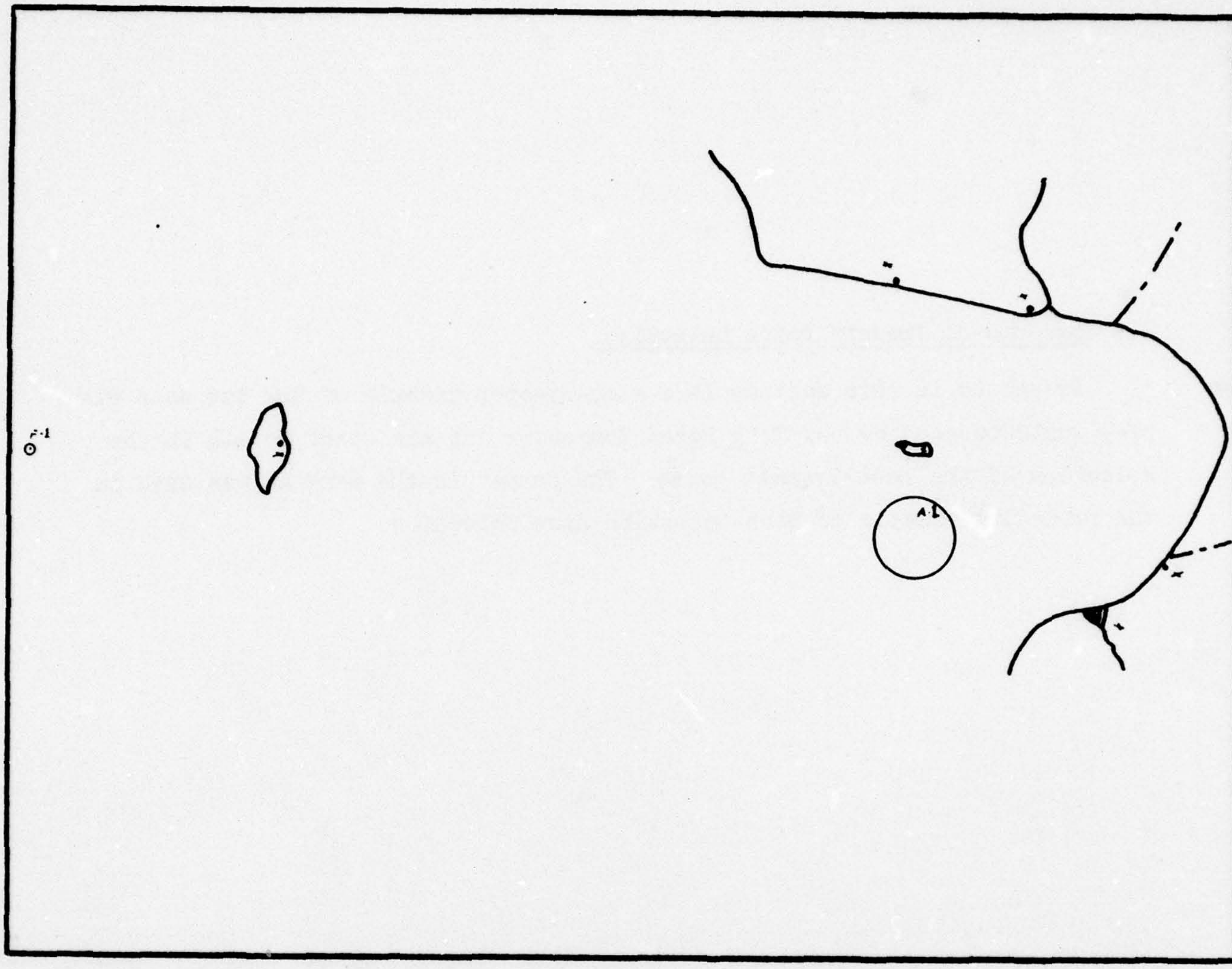


FIGURE 2-29 THEATER MAP

The user, having selected the Transit Route Mode, is shown Figure 2-30 - Transit Route Select Menu on the right screen in which he is requested to select the categories he wishes to examine. The user would normally call up and examine all seven categories shown in Figure 2-30, one at a time and in the listed order, although he has the option of not calling up all the categories. On the left screen Figure 2-29 - Theater Map is displayed, which shows a graphical map picture of the mission area large enough to include his present location and all possible destinations for the previously established mission.

```
TRANSIT ROUTE SELECT
--------------------

C1 - TIME/DISTANCE CAPABILITY
C2 - ENVIRONMENT
C3 - SURVEILLANCE CAPABILITY
C4 - VULNERABILITY
C5 - ROUTE DEFINITION
C6 - AVERAGE THREAT LEVEL
C7 - RELATIVE MOVEMENT

ENTER
-----
C-
```

FIGURE 2-30 TRANSIT ROUTE SELECT MENU

As each category is called by the user a series of displays will be shown, some of which request more information, allowing the user to peruse formatted data germane to his decision making process and simulate certain trial conditions. In order to demonstrate the full capability available to the user, the displays associated with all seven categories will be shown on the following pages in the order listed in Figure 2-30.

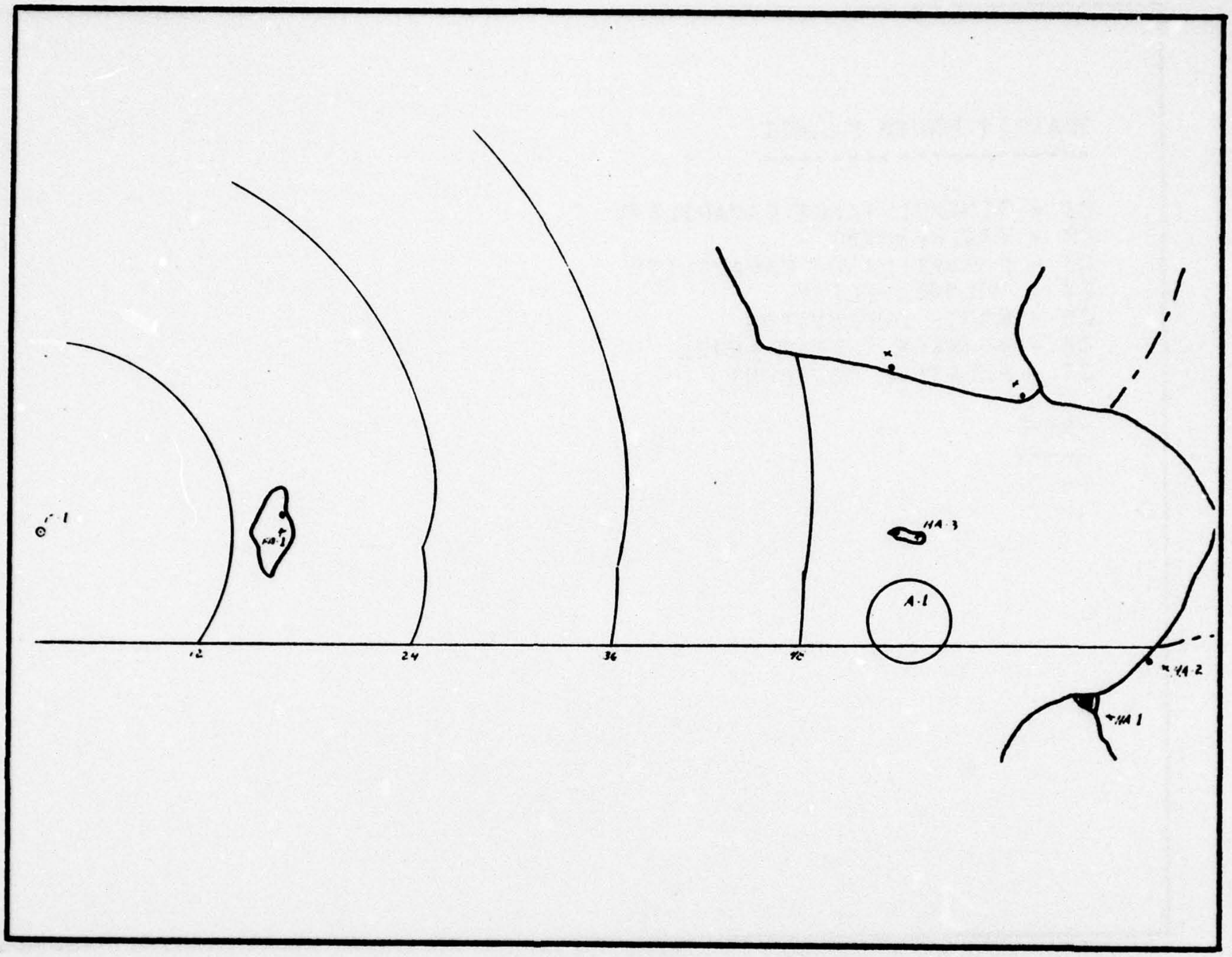


FIGURE 2-31 TF FURTHEST-ON POSITIONS

The user, having selected the TIME DISTANCE CAPABILITY category, would be presented with an interactive display, Figure 2-32 - Time/Distance Capability Prompt, which requests further information. The user enters the present position and speed of advance of the Task Force, the time increment for which the extrapolated positions are to be calculated and the length of the time (time period) over which the extrapolations are to extend. The extrapolated or Furthest-On positions that could be reached by the Task Force are then shown in Figure 2-31 -

```
TIME/DISTANCE CAPABILITY
------------------------

L = LATITUDE OF PRESENT POSITION
O = LONGITUDE OF PRESENT POSITION
S = SPEED OF ADVANCE
T = TIME INCREMENT
P = TIME PERIOD

ENTER
-----
L-,- (DEGREES, MINUTES)
O-,- (DEGREES, MINUTES)
S- (KNOTS)
T- (HOURS)
P- (HOURS)
```

FIGURE 2-32 TIME/DISTANCE CAPABILITY PROMPT

TF Furthest-On Positions on the left screen as an overlay of the Theater Map. Included in Figure 2-31 are the boundary constraints previously established under OPERATING CONSTRAINTS while selecting the Best Operating Area. For the example shown in Figure 2-31, the time increment is 12 hours and the time period is 48 hours. The curves represent the locus of points that could be reached by the Task Force in each 12 hour increment and gives the user an appreciation of his time-distance capability. The effects of altering course to avoid land mass, shoals and prohibited areas are included.

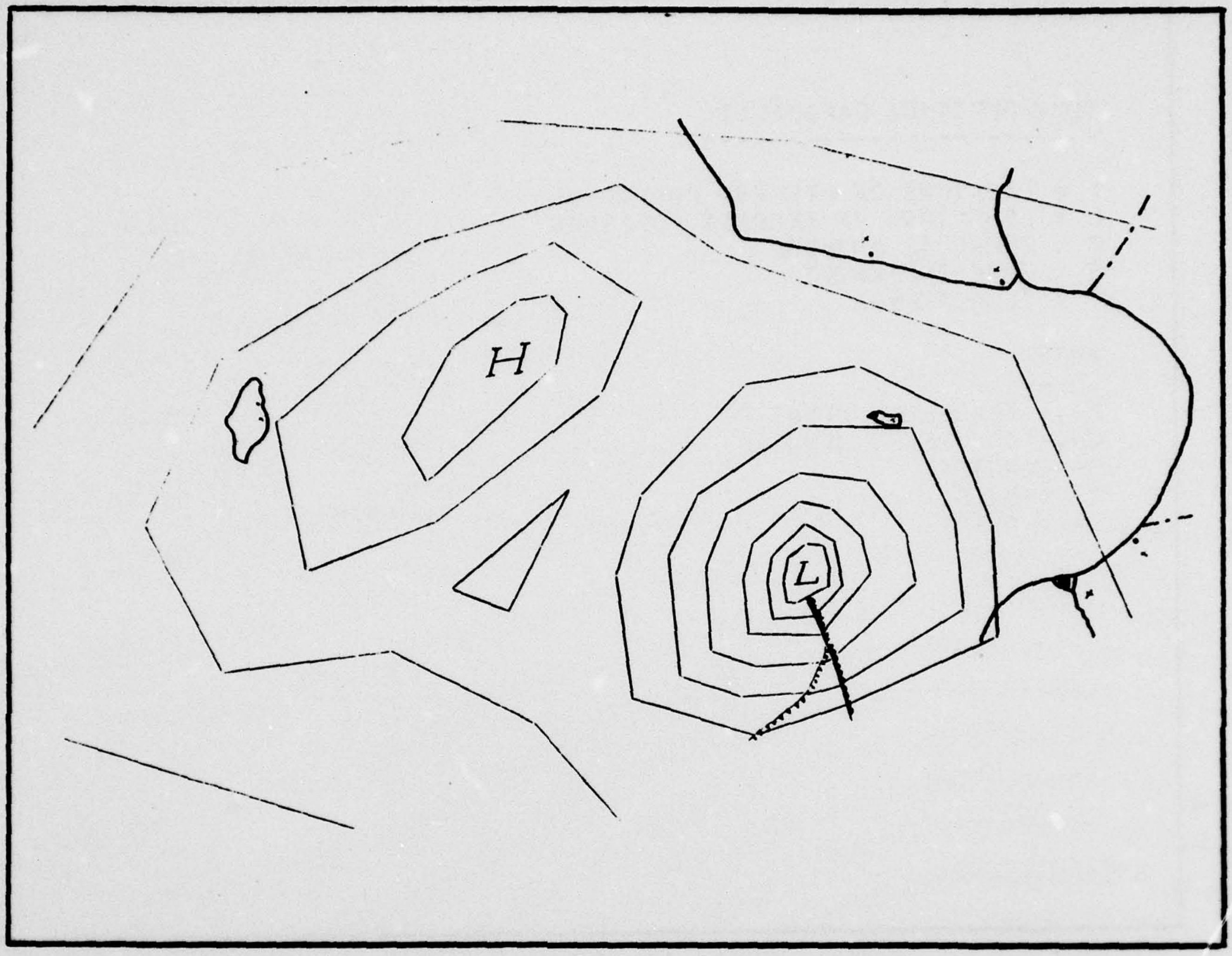


FIGURE 2-33 SYNOPTIC WEATHER CHART

The user, having examined the Task Force Time Distance Capability, can now explore the effects of environment on his transit route selection. He would call up Figure 2-30 and select C2 - ENVIRONMENT. Figure 2-34 - Environment Menu would be displayed on the right screen. The user would select the desired environment feature and it would be graphically displayed on the left screen. The area weather can be displayed either as a conventional synoptic weather chart as shown in Figure 2-33 or, if information is available, as a dot grid presentation where the density of the dots corresponds to wind, precipitation or sea state. The operator must also designate from the menu in

```
ENVIRONMENT
-----------

E1 - AREA WEATHER CHART
E2 - WIND
E3 - PRECIPITATION
E4 - SEA STATE
T (HRS) - TIME OF INTEREST FROM PRESENT

E5 - HYDROGRAPHY
E6 - SONAR DETECTION PARAMETERS

ENTER
-----
E-
T-
```

FIGURE 2-34 ENVIRONMENT MENU

Figure 2-34 the Time of Interest (i.e., weather now or that predicted "X" hours from now), and dot grid or chart presentation. Other environment parameters the user may select and observe on the left screen are: Hydrography - depth contour lines, shoals - and sonar detection parameters. The selected environmental parameter is always overlayed on the same map background in order to constrain the software requirements.

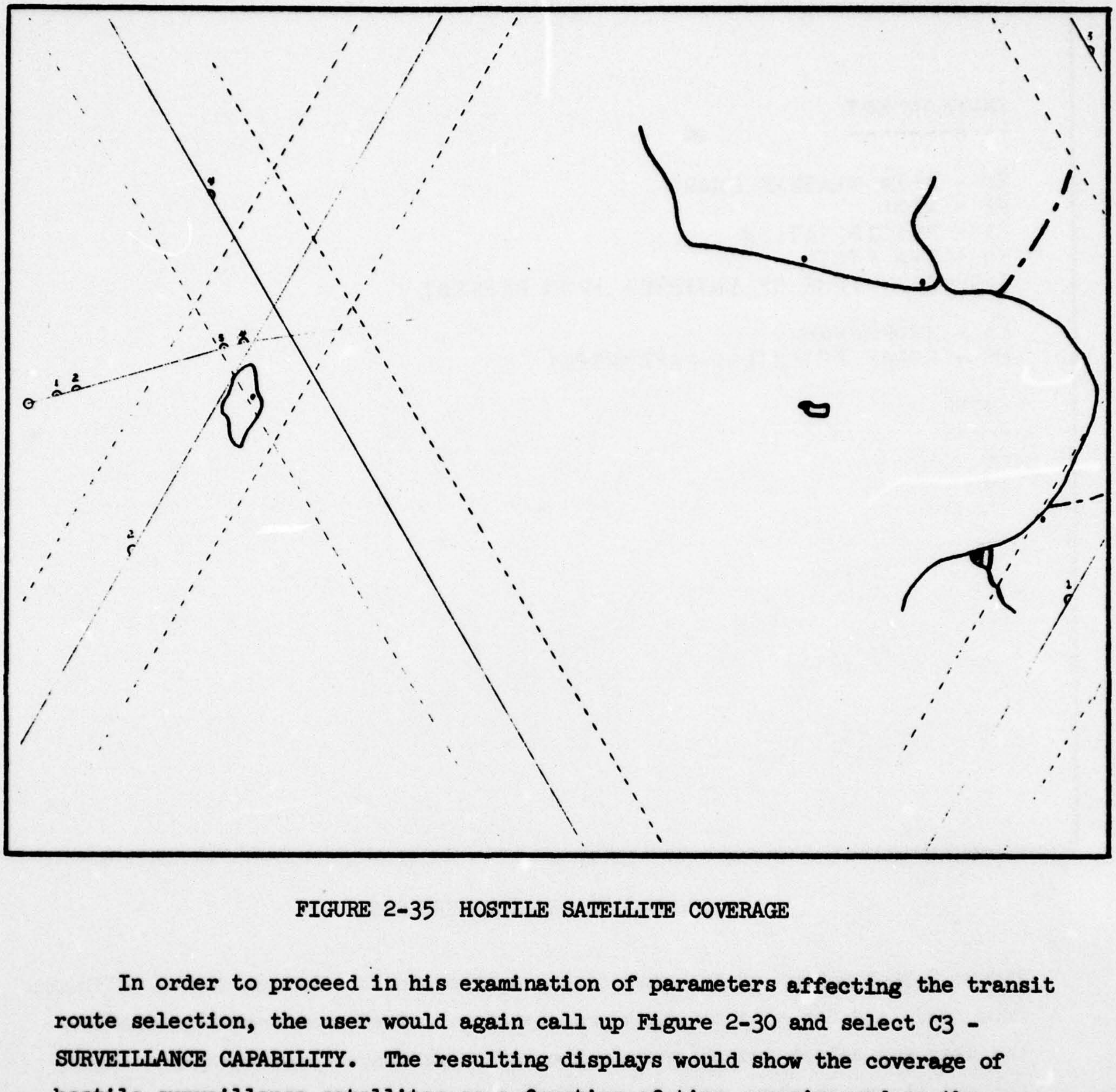


FIGURE 2-35 HOSTILE SATELLITE COVERAGE

In order to proceed in his examination of parameters affecting the transit route selection, the user would again call up Figure 2-30 and select C3 - SURVEILLANCE CAPABILITY. The resulting displays would show the coverage of hostile surveillance satellites as a function of time superimposed on the theater map background. Examination of these displays would permit the user to plan his transit route to either coincide with the satellite coverage if he wishes to announce his intentions or temporarily avoid the satellite coverage if he wishes to operate covertly as long as possible.

In the context of the ONRODA theater situation it is desirable that the Orange and Red authorities are apprised that the Task Force is moving and will constitute a threat to the Oranges Forces on ONRODA, but not to the Red Task Force. The achievement of this goal would be enhanced by planning the transit route to

```
HOSTILE SATELLITE SURVEILLANCE
------------------------------

TB - BEGINNING OF COVERAGE TIME PERIOD
TE - END OF COVERAGE TIME PERIOD
 N - SATELLITE NAME AND ID NUMBER
LP - PRESENT LATITUDE
QP - PRESENT LONGITUDE
 S - SPEED OF ADVANCE
 C - COURSE

ENTER
-----
TB-
TE-
 N-
LP-
QP-
 S-
 C-

SWATH INTERCEPTION (4)
----------------------
  LAT XX,XX
  LONG XXX,XX
  TIME 020947Z
```

FIGURE 2-36 HOSTILE SATELLITE SURVEILLANCE PROMPT

coincide with the satellite coverage as soon as possible. Figure 2-36 - Hostile Satellite Serveillance Prompt would be displayed on the right screen, which requests the user to identify the beginning and end time of the period for which he wishes to see the satellite coverage and to identify the satellite. The user also enters his present position, course and speed. When the user makes his selections called for in Figure 2-36 a graphical display Figure 2-35 - Hostile Satellite Coverage appears on the left screen. This figure shows the satellite coverage and the user's dead reckoned position at each satellite pass. In the example shown the beginning time corresponded to 0500 hours and the end time 0200 hours the next day. Satellite passes occurred at the times associated with positions 1, 2, 3 and 4 as shown in Figure 2-35. It can be noted the user comes under the satellite surveillance coverage at position 4 and is noted in Figure 2-36.

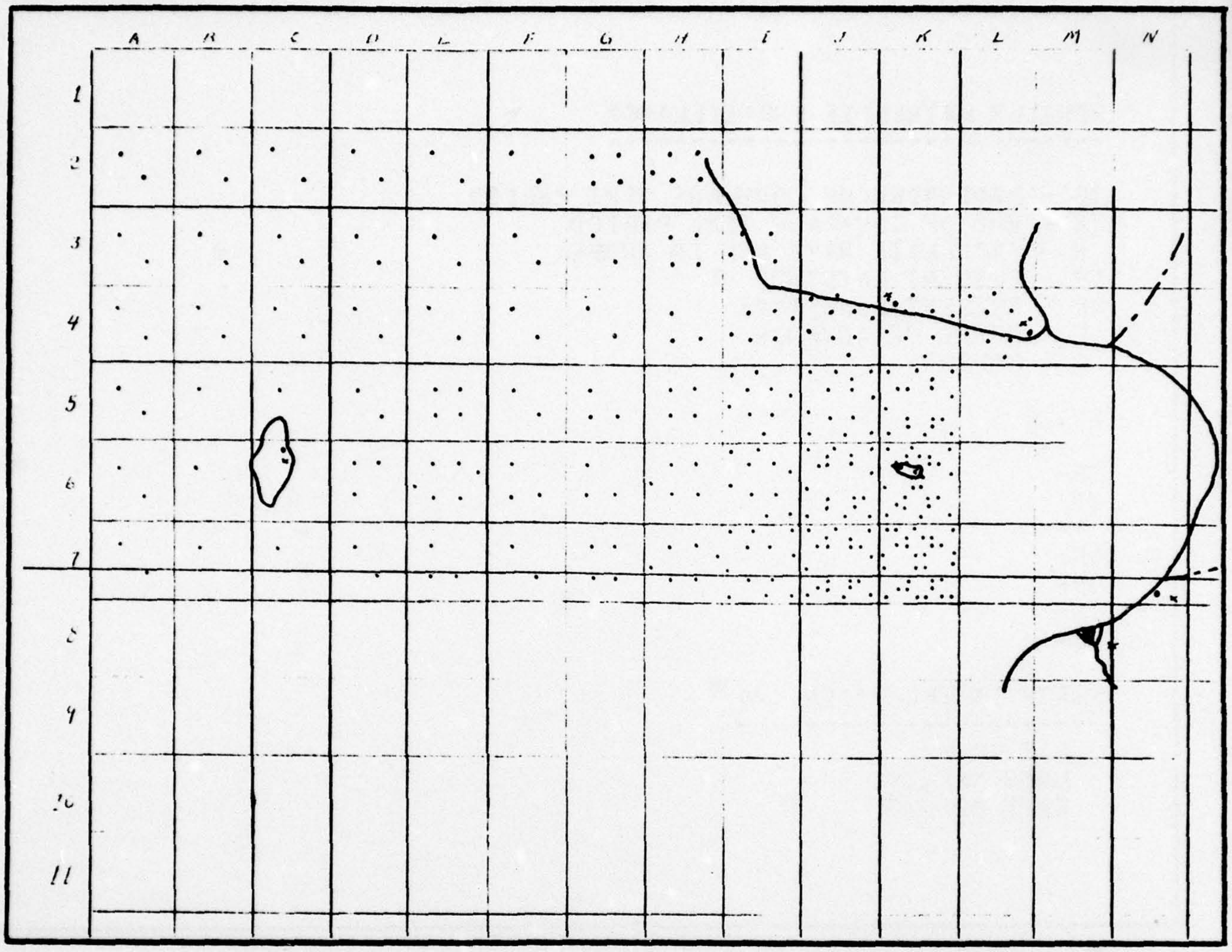


FIGURE 2-37 COMPOSITE THREAT VULNERABILITY

The user would now examine how vulnerable his Task Force would be to enemy threats as he passed through various geographical areas. This is done by calling up Figure 2-30 and selecting C-4 VULNERABILITY. Figure 2-38 - Threat Vulnerability Menu would appear on the right screen in which the user is requested to select the type of threat: air, surface, sub-surface or composite (all threats) and the time for which the threat levels are to be calculated. The vulnerabilities would be calculated and displayed as shown in Figures 2-11 through 2-22 in the Ops Area Selection section. For example air vulnerability can be expressed as kilotons per day that can be delivered in specific geographic areas, or as probability of the Task Force being neutralized by Orange Force in specific geographical areas. Surface/sub-surface vulnerability

```
THREAT VULNERABILITY
--------------------

V1 - AIR THREAT
   1 - KILOTONS/DAY
   2 - PROBABILITY OF NEUTRALIZATION

V2 - SURFACE THREAT
   1 - NUMBER OF MISSILES
   2 - PROBABILITY OF NEUTRALIZATION

V3 - SUB-SURFACE THREAT
   1 - NUMBER OF MISSILES
   2 - PROBABILITY OF NEUTRALIZATION

V4 - COMPOSITE OF ALL THREATS

ENTER
-----
V-,-
```

FIGURE 2-38 THREAT VULNERABILITY MENU

can be displayed as missile delivery capability or as probability of neutralization. The distance the surface and sub-surface threats can travel until the specified time is reached is also included in their weapon coverage as in the Ops Area selection case. If the user desires to go directly to the total composite effect of considering all threats by choosing V4 - COMPOSITE in Figure 2-38, a dot grid presentation would be displayed on the left screen as shown in Figure 2-37 - Composite Threat Vulnerability. The user would try to select a course that passes through the areas of least dot density when considering own Task Force vulnerability.

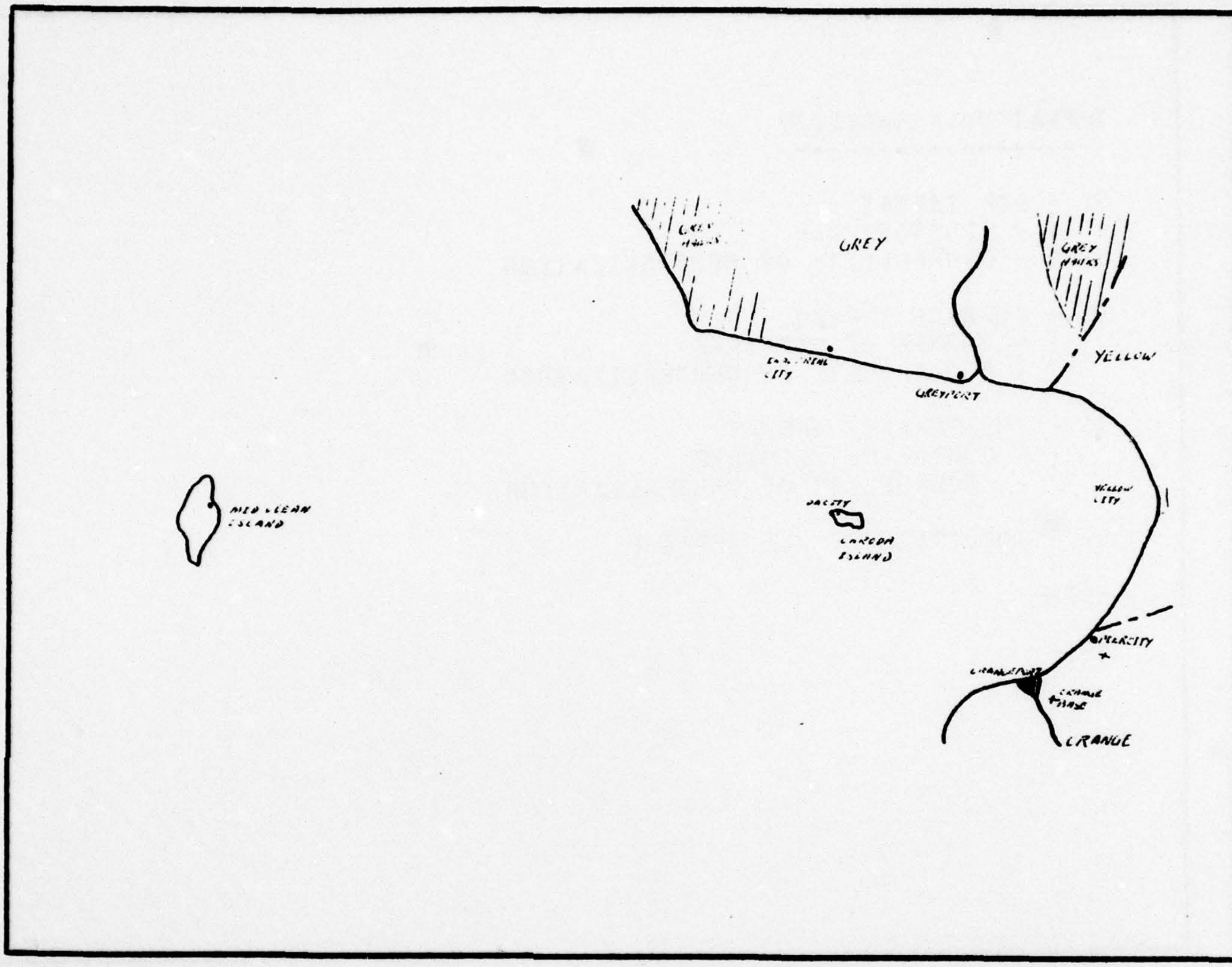


FIGURE 2-39 TRANSIT AREA CHART

The user may now wish to examine the time-distance relationships that would result from certain selected transit routes. The user would call up Figure 2-30 and select C5 - ROUTE DEFINITION. Figure 2-40 - Route Definition Parameters would then be displayed on the right screen and Figure 2-39 - Transit Area Chart on the left screen. The user would enter the latitude and longitude of his start point, up to nine way points (intermediate points to be passed through along the way), and his final destination. An alternate way of describing the transit route would be "hooking" all the points with a light pen or similar device on Figure 2-39. The speed of

```
ROUTE DEFINITION
----------------

L0 - LAT OF START POINT
Q0 - LONG OF START POINT
L1 - LAT OF FIRST WAY POINT
Q1 - LONG OF FIRST WAY POINT
LN - LAT OF NEXT WAY POINT (UP TO N = 9)
QN - LONG OF NEXT WAY POINT (UP TO N = 9)
L10 - LAT OF DESTINATION
Q10 - LONG OF DESTINATION
S1,2 - SPEED OF ADVANCE FROM POINT 1 TO POINT 2
       OF ANY OTHER TWO POINTS
TN - LAYOVER TIME AT POINT N

ENTER
-----
L- (DEGREES, MINUTES)
Q- (DEGREES, MINUTES)
S-,- (KNOTS)
T- (HOURS)
```

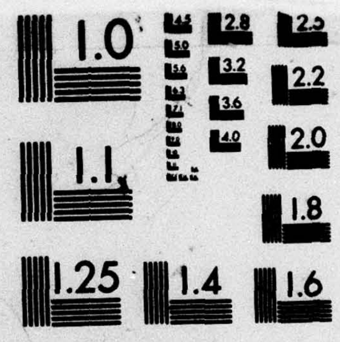
FIGURE 2-40 ROUTE DEFINITION PARAMETERS

advance between each two points may be entered, or, if the speed is to remain constant over several legs, only the beginning and end points over which the speed is to remain constant is entered (i.e., S6, 7). If a rendezvous is to occur or there is a requirement to remain at a way point for a period of time (e.g., take on fuel) this data is entered by identifying the way point and entering the hours to remain on station. (i.e., T6 - 14) for each applicable way point.

AD-A035 755 EXPERIMENTAL VALIDATION OF AN OPTIONS SELECTION MATRIX AND INVESTIGATION O..(U) GRUMMAN AEROSPACE CORP BETHPAGE N Y COMMAND SUPPORT SYSTEMS G.. 2/2

UNCLASSIFIED C R KALENTY ET AL. FEB 77 CSS-77-1 F/G 12/2 NL

END
DATE
FILMED
7-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

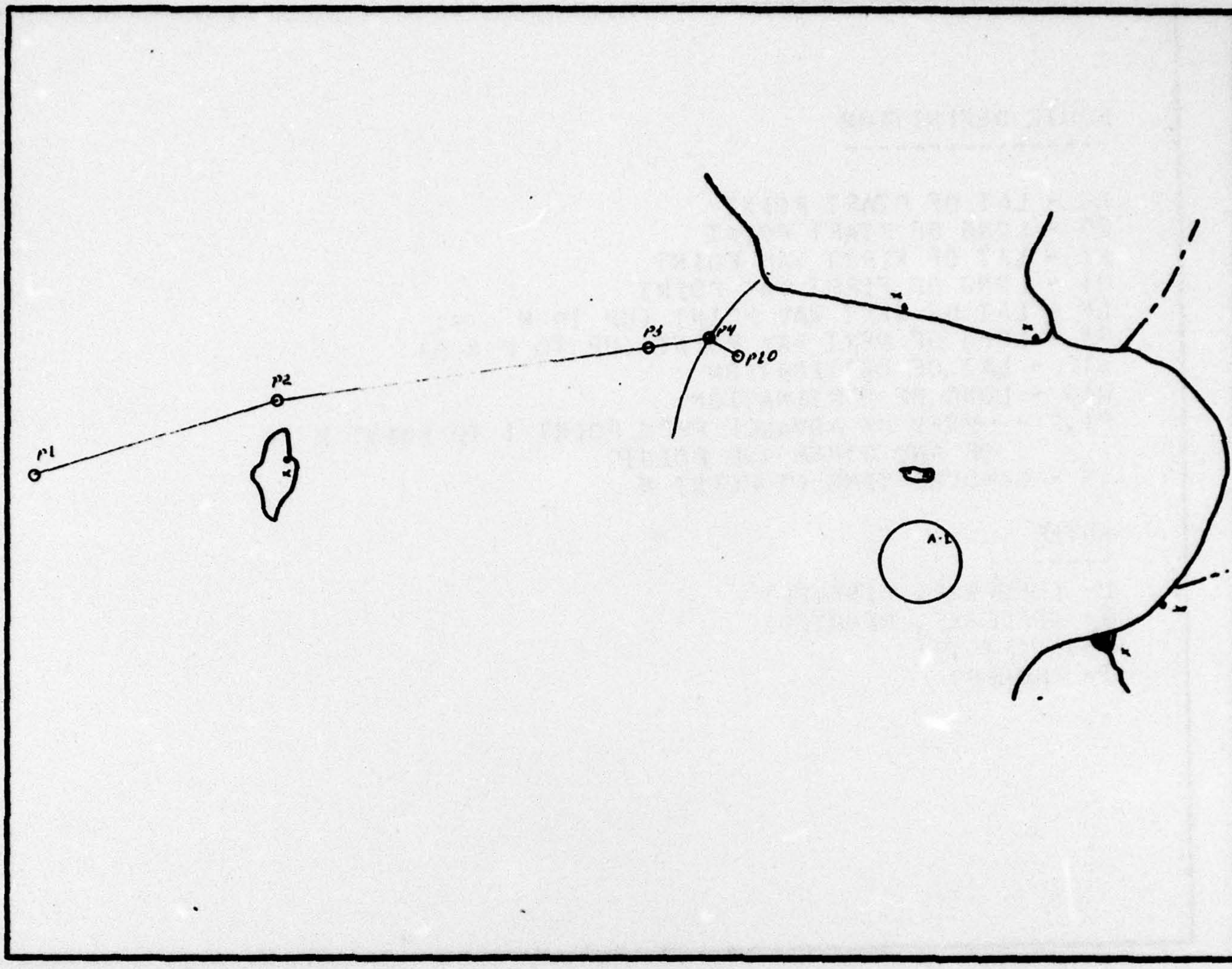


FIGURE 2-41 TRANSIT AREA ROUTE CHART

Upon establishing the requirements for a trial transit route as described with Figures 2-39 and 2-40, the user would be presented with two displays. Figure 2-41 - Transit Area Route Chart, which shows the trial transit route superimposed on the area map, is presented on the left screen and Figure 2-42 - Route Parameters is presented on the right screen. Figure 2-42 shows the Latitude, Longitude and the layover time (LO) at each point. The Speed of Advance (SOA), Distance, Course and Time between successive points is also shown. In the sub-total row the SOA is calculated by dividing the total distance travelled by the time to travel each leg not including

ROUTE PARAMETERS

POSIT	LAT	LONG	LO TIME	SOA	C	DISTANCE	TIME
P1	XX,XX	XXX,XX	0	-	-	0	0
P2	XX,XX	XXX,XX	0	20	074	460	23
P3	XX,XX	XXX,XX	6	20	082	680	34
P4	XX,XX	XXX,XX	0	30	082	115	3.3
P10	XX,XX	XXX,XX	0	30	121	65	2.2
SUB-TOTAL			6	20.9	-	1320	63
TOTAL				19.1	-	1320	69

ENTER

(F) FOR FINISH, OR (N) FOR NEXT TRIAL

FIGURE 2-42 ROUTE PARAMETERS

layover time. In the total row SOA and total time includes the layover time. If the user desires to try other transit routes he would enter N and Figures 2-39 and 2-40 would again appear allowing the user to enter different parameters and run the case again. It would be more convenient for the user if a light pen method of transit route entry was mechanized. He could then trace trial routes on the map display, avoiding obstacles or high threat areas (which could also be displayed on the map background).

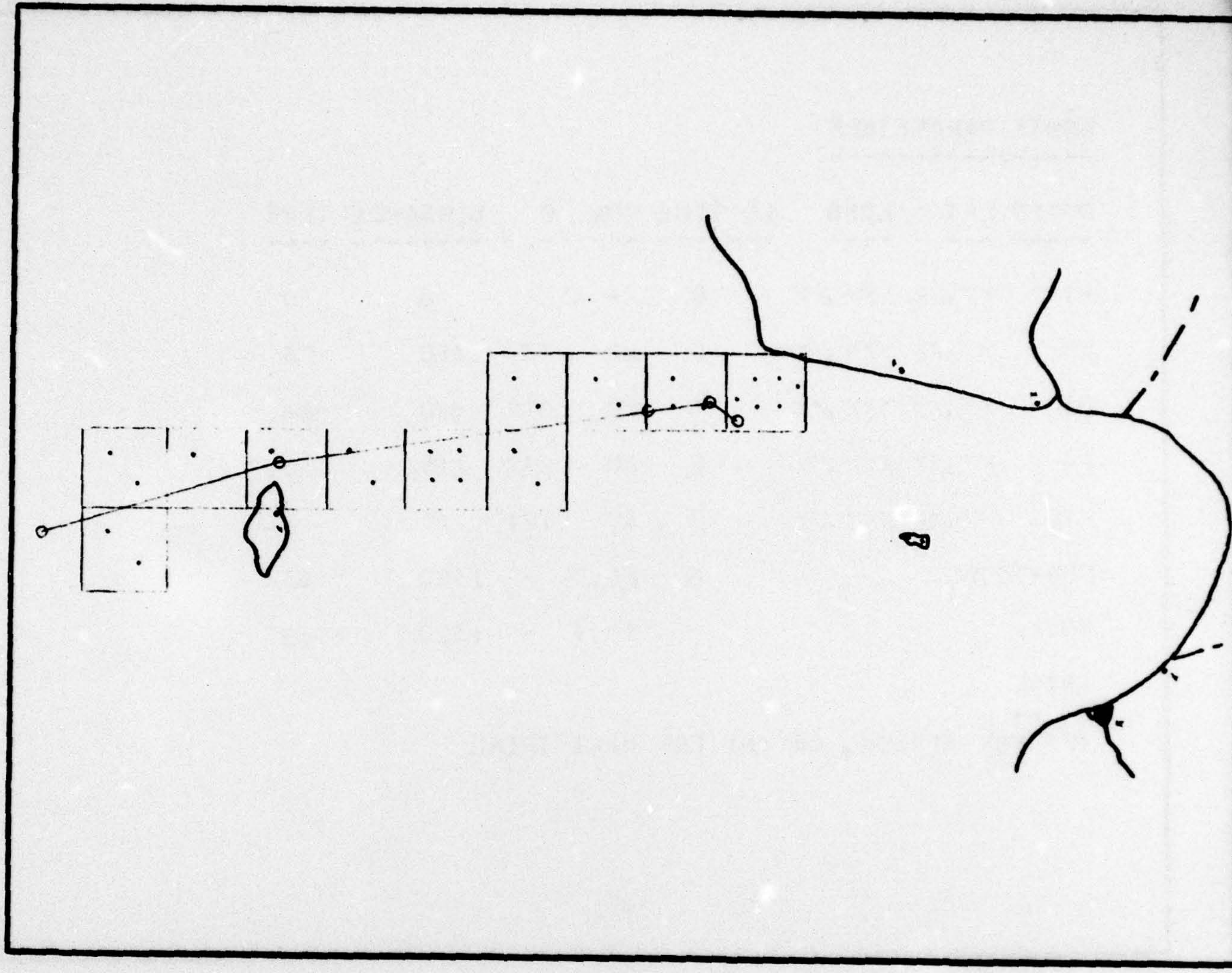


FIGURE 2-43 AVERAGE THREAT LEVEL

The user may also elect to examine the average hostile threat level to which the Task Force will be exposed for a selected transit route. To do this he would call up Figure 2-30 and select C6 - AVERAGE THREAT LEVEL. Figure 2-44 - Average Threat Level Prompt would appear on the right screen requesting information similar to that described in the discussion of Figure 2-42. A map display similar to Figure 2-41 would be presented on the left screen on which the user could trace, with a light pen, the trial route if desired. If no information is entered for the transit route coordinates, the route last defined under the ROUTE DEFINITION category would be used. Once the tentative transit route is defined, Figure 2-43 - Average Threat Level is displayed on the left screen. This figure shows

```
AVERAGE THREAT LEVEL
--------------------

LO - LAT OF START POINT
QO - LONG OF START POINT
L1 - LAT OF FIRST WAY POINT
Q1 - LONG OF FIRST WAY POINT
LN - LAT OF NEXT WAY POINT (UP TO N = 9)
QN - LONG OF NEXT WAY POINT (UP TO N = 9)
L10 - LAT OF DESTINATION
Q10 - LONG OF DESTINATION
T - TIME OF INTEREST FROM PRESENT
P1 - DOT DISPLAY MODE
P2 - NUMERICAL DISPLAY MODE

ENTER
-----
L- (DEGREES, MINUTES)
Q- (DEGREES, MINUTES)
T- (HOURS FROM PRESENT TIME)
P1 OR P2

AVERAGE THREAT LEVEL VALUE
--------------------------
  PREVIOUS RUN  4.3
  THIS RUN      3.7
```

FIGURE 2-44 AVERAGE THREAT LEVEL PROMPT

the grid squares with their respective dot densities that the Task Force passes through along the selected transit route. Associated with each grid square is a Figure of Merit (FOM) similar to Figure 2-37 which represents the vulnerability of the Task Force while passing through that square. The FOM's are averaged to produce a number for the average threat level the Task Force will experience for the selected route. This number is displayed in Figure 2-44. The user may select alternate transit routes for evaluation and, as noted in Figure 2-44, the FOM's from both the previously and presently selected transit routes are displayed.

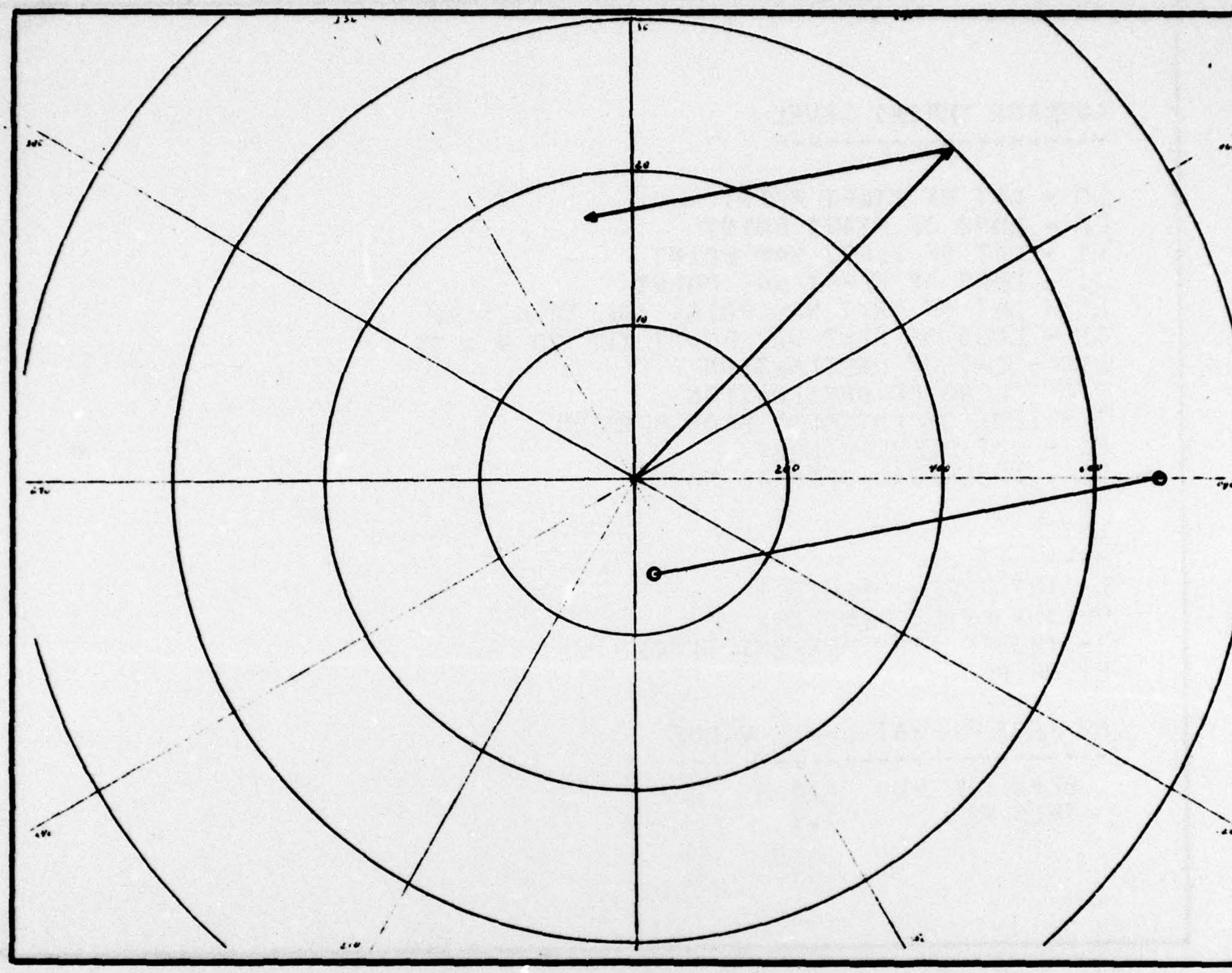


FIGURE 2-45 RELATIVE MOTION DIAGRAM

The user has one more category he may examine to aid him in selecting the best transit route, and that is the use of a maneuvering board type display to analyze relative movement situations, typically, between the Task Force and a threat. A need to exercise this capability may arise, for example, if information is received that an Orange Whiskey Class Submarine has been detected along the planned transit route. The user may wish to avoid the threat by altering his course to pass the submarine no closer than 120 n.mi. to remain outside his missile range. Assuming the submarine chooses the optimum course for intercept and closes at 17 knots while the task force speed of advance is 30 knots, the required Task Force course to perform this "end run" can be determined as well as time and distance to CPA (closest point of approach) and location of CPA. Although problems of this type would be solved by the computer and numerical answers displayed as in Figure 2-46 - Relative Motion Parameters, it is felt a maneuvering board type of

```
ENTER
-----

R - CPA RANGE (NMI)
S1 - OWN SPEED (KTS)
S2 - THREAT SPEED (KTS)
L1 - OWN LATITUDE (DEG, MIN)
Q1 - OWN LONGITUDE (DEG, MIN)
L2 - THREAT LATITUDE (DEG, MIN)
Q2 - THREAT LONGITUDE (DEG, MIN)

SOLUTION
--------

OWN COURSE 046 DEG
TIME TO CPA 26.1 HR
DISTANCE TO CPA 752 NMI
LAT AT CPA XX,XXN
LONG AT CPA XXX,XXE
```

FIGURE 2-46 RELATIVE MOTION PARAMETERS

presentation shown in Figure 2-45 - Relative Motion Diagram would be useful. Navy personnel are experienced with maneuvering board displays and such a display would enable such users to determine if the computer solutions are reasonable and would give them increased confidence in the solutions. By analyzing the maneuvering board display a user can visually estimate the relative motion parameters that would occur with alternate inputs of course, speed and distance without having to actually input data and run a computer solution. To use the foregoing capability the user would call up Figure 2-30 and select C7 - RELATIVE MOVEMENT. Using Figure 2-46, he would enter the necessary parameters, and the results would appear as alphanumerics on Figure 2-46, and as graphics on Figure 2-45. Of course many other types of relative motion problems than those illustrated may be solved with this approach.

The user, having utilized the capabilities that may be exercised by calling up any or all of the seven transit route selection categories, is now in a position to make a decision. Some of the data display decision aids he has examined point him toward a specific transit route or routes considering that one category only (e.g., vulnerability). However, an attempt is not made to combine, through the computerized mechanization, the results from all the categories. The relative importance of each category in formulating the final decision must be left to the user.

2.8 Proposed Experiment to Test the Efficacy and Acceptance of Data Display Sequences

Experience gained in the course of current effort indicates that the technique of exposing a test population comprised of experienced naval officer subjects to a sequence of displays in the context of a prepared scenario is a very effective method to establish the degree of utility of selected presentation modes and information formats by comparison to other candidate displays, and the degree of enthusiasm associated with their acceptance by operationally oriented personnel.

Further experimental evaluation to investigate these aspects appears to be indicated. Such an evaluation program would comprise the following major tasks:

- Adaptation of existing scenario material to more specifically define and highlight the courses of action available in each of two involved decisions (Ops Area Select and Transit Route Select).
- Preparation and formatting of supportive data using each of four techniques

  Tabular presentation
  Isogram charts
  Numerically labelled configuration
  Dot grid

- Comparative simulation testing by a population consisting of operationally experienced subjects to provide both objective and subjective evaluations based on application in two related decisions.

- Restructuring as required to facilitate the derivation of a logically "correct" solution for control purposes.
- Elicitation and analysis of subject reaction and comments.
- Generation of report describing experimental results.

Since a significant portion of the results to be obtained from these tests would consist of subjective evaluation of the data display sequence methodology, the degree of experience and familiarity of the test subjects with the field of command and control in naval operations is of prime importance. It is considered that a test technique utilizing a population composed of experienced senior naval personnel in an interactive war-room simulator system as was done with the Options Selection Matrix experiments provides the most effective approach to actual shipboard system evaluation that is practically attainable.

2.9 Conclusions and Recommendations

A series of interactive graphic and alphanumeric displays that could assist a user in formulating decisions in two specific tactical situations have been presented. Although details of the software requirements to generate these displays are not discussed, these requirements have been considered as the displays were conceived. Many of the displays (i.e., dot grid, missile coverage, satellite coverage, time-distance-course plots, etc.) are presently operating in similar form in the ITFCC program. Grumman developed the algorithms and code necessary to implement these types of displays in a DEC PDP-11/45 mini-computer presently installed aboard the JFK under contract to NAVELEX on the ITFCC program.

The following factors were given major consideration during the conception of decision methodology.

- Allow maximum utilization of the user's judgement and skills by implementing an interactive system which permits the user to accept, override or alter the processed data.
- Present information in common formats and procedures to expedite user interpretation.

- Permit the user to proceed directly to a computer generated solution for minor decision points in a panic situation when speed is crucial or permit the user to examine many detailed facets of the problem step-by-step as his work load allows.

Although the display formats were structured around solving two specific decision problems, they have a broad spectrum of applications, especially where geographical considerations are involved.

This report has presented data displays as they would appear and be used by operational personnel. The next step would be to develop new and modify existing software necessary to generate these displays and provide the interactive capability. At this point the computer sizing requirements and the cost of implementing a demonstration model could be determined. The concluding step would be to implement a demonstration system and conduct a validation test as discussed in paragraph 2.8.